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VOL. XXV

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Middle Devonian Ostracoda from Oil Wells in Southwestern Ontario

By

MARY C. TURNER

August 12, 1939

PALEONTOLOGICAL RESEARCH INSTITUTION
Ithaca, New York
U. S. A.

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AUG 1 9 1939

MIDDLE DEVONIAN OSTRACODA FROM OIL WELLS IN SOUTHWESTERN ONTARIO

By

MARY C. TURNER

INTRODUCTION

GEOGRAPHIC AND STRATIGRAPHIC LOCATION OF FAUNA

The presence of a microfauna in the Devonian strata of Ontario has been known since the early geological surveys were made, but, it has not been intensively studied until recent years. In 1935, a study of this microfauna, as represented in well cuttings from the oil and gas fields of southwestern Ontario, was initiated by the Geological Survey of Canada for the purpose of determining its usefulness in the study of stratigraphy.

Dr. M. A. Fritz (1), as the result of a preliminary study of these fossils, recently described seven microfossil zones in the Devonian strata encountered in the wells of the more important fields. The fields included were the Dover, Dawn, D'Clute, and East Tilbury, all of which are located in Kent and Lambton counties. With the aid of these zones, the horizon marker commonly used by drillers, the top of the Big Lime, was shown to be variable throughout the fields and, therefore, unreliable. At the same time a new horizon marker, the bottom of the Big Lime, was established. The fossil zones recognized are: Upper Spore zone; Upper Ostracode zone; Pteropod zone; Bryozoa zone; Lower Spore zone; *Trochiliscus* zone; and Lower Ostracode zone.

The Upper Ostracode zone is described as, "a particularly well marked horizon, extending throughout the bluish-gray calcareous shales of the Hamilton formation; these shales attain a thickness in certain wells of approximately 100 feet." The ostracodes from this zone are herein discussed.

This study was suggested as an M.A. thesis problem by Dr. Fritz whose helpful opinion and criticism throughout the preparation of the thesis I wish to acknowledge.

Aug 18

HISTORICAL REVIEW

The ostracodes constitute one of the most important elements in the microfauna of the Middle Devonian of southwestern Ontario. These minute fossils were considered by a few of the early workers, but no exhaustive studies were made.

As early as 1874, Nicholson (2), described the most typical species in this fauna, namely, *Ponderodicyta punctulifera* (Hall), from the Hamilton formation, Widder, Ontario. Later, Jones in 1890 (3), writing on Palæozoic ostracodes, described additional species from the Hamilton formation at Thedford and Arkona, Ontario. In 1915, Stauffer (4), recorded several typical species in his report on the Devonian of southwestern Ontario. The great abundance of the ostracode fauna in this area has been indicated only recently, in 1936, when Coryell and Malkin (5), described a large number of species from the Widder beds at Arkona, Ontario.

PREPARATION AND PREVIOUS STUDY OF MATERIAL

The ostracodes described and discussed in this paper form part of a collection of microfossils assembled by the Geological Survey of Canada, in connection with the previously mentioned study. The collection from the well samples was supplemented by specimens from surface exposures of the Hamilton formation at Thedford, Ontario. These were used for comparative purposes in this study.

The material was loaned to the Department of Geology, at the University of Toronto, for further examination. The present research was carried on at the Royal Ontario Museum, Toronto.

In a preliminary study of the ostracodes, Dr. Fritz determined the various types represented in the collections and made tentative generic identifications. This work, greatly facilitated the present study.

FAUNAL SUMMARY

The majority of the ostracodes in the collection are typical Devonian forms. Thirty-one species have been identified. Nine new species and two new varieties of hitherto known species have been described. One new genus, *Boursella,* a minute, well marked form, not uncommon in the well cuttings, has been erected. The identified species are:—

Haploprimitia punctata, n. sp.
Ulrichia conradi Jones
Ulrichia fragilis Warthin, var. subnodata, n. var.
Boursella trilobata, n. sp.
Halliella bellipuncta (VanPelt)
Tetradella cicatricosa Warthin
Hollinella granifera (Ulrich)
Hollinella subcircularis, n. sp.
Hollinella, sp.
Dizyogopleura euglyphea Warthin
Dizygopleura trisinuata VanPelt
Dizygopleura sculptura, n. sp.
Poloniella cingulata Warthin
Eukloedinella doverensis, n. sp.
Amphissites subquadratus (Ulrich)
Amphissites parallela (Ulrich)
Octonaria quadricostata VanPelt
Octonaria cf. crescentiformis VanPelt
Euglyphella sigmoidalis (Jones)
Bufina lineata, n. sp.
Lucasella mundula Stewart
Menoeidina subreniformis Stewart
Menoeidina arcuata, n. sp.
Ponderodictya punctulifera (Hall)
Ponderodictya ohioensis (Stewart)
Quasillites obliquus Coryell and Malkin
Quasillites reticulata, n. sp.
Quasillites fordei Coryell and Malkin, var. minimus, n. var.
Spinovina distributa Coryell and Malkin
Jenningsina concentrica, n. sp.
Entomis, sp.

The relative abundance of the different genera and species varies greatly. Two genera in particular, *Ponderodictya* and *Quasillites,* occur in great numbers and varieties of form throughout all the wells in the four fields considered. In other instances, only one or two specimens of a particular species have been found, as in the case of *Eukloedinella doverensis,* n. sp., and *Halliella bellipuncta* (VanPelt), each being represented by a single specimen. Table I shows the occurrence of the ostracodes in the wells, grouped in their respective fields.

COMPARISON OF SIMILAR FAUNAS IN RELATED AREAS

A similar assemblage of Middle Devonian ostracodes has been described in recent years from the Bell shale, Michigan (6), from the Traverse group, Michigan (7), from the Silica shale, Ohio (8), and the Widder beds at Arkona, Ontario (5). Table II gives the occurrence of the species listed above in these related areas. It will be noted that this area has more species in common with the areas in Michigan and Ohio than the Widder beds, Arkona.

TABLE I: Occurrence of Species in the Various Fields

Species	Tilbury Field	Dover Field		D'Clute Field								Dawn Field	
	Eugene Coste 6	Union 19	Dauphin Imperial 2	D'Clute 14	Lethwaite 24	Moore 26	D'Clute 19	Union D'Clute Sykes 12	Union D'Clute Storey 15	Union D'Clute Ronson 11	Olga 5	Union 61	Union 67
Amphissites parallela (Ulrich)		x											
Amphissites subquadrata (Ulrich)		x											
Boursella trilobata, n. gen., n. sp.				x	x	x		x	x		x		
Bufina lineata, n. sp.		x	x										
Dizygopleura euglyphea Warthin	x	x										x	
Dizygopleura trisinuata Van Pelt			x										
Dizygopleura sculptura, n. sp.		x		x	x						x		
Entomis, sp.					x								
Euglyphella sigmoidalis (Jones)		x	x	x		x						x	
Eukloedinella doverensis, n. sp.		x											
Halliella bellipuncta Van Pelt			x										
Haploprimitia punctata, n. sp.					x		x						
Hollinella granifera (Ulrich)	x												
Hollinella subcircularis, n. sp.								x					
Hollinella, sp.								x					
Jenningsina concentrica, n. sp.					x	x		x					
Lucasella mundula Stewart								x	x				
Menoeidina arcuata, n. sp.		x	x				x	x		x	x	x	x
Menoeidina subreniformis Stewart								x					
Octonaria cf. crescentiformis Van Pelt	x											x	
Octonaria quadricostata Van Pelt	x			x	x							x	
Poloniella cingulata Warthin		x			x								x
Ponderodictya punctulifera (Hall)	x	x	x	x	x	x	x	x	x	x	x	x	x
Quasillites fordei, var. minimus n. var.		x			x	x							
Quasillites obliquus Coryell and Malkin	x	x	x		x	x	x	x	x	x	x	x	x
Quasillites reticulata, n. sp.		x			x		x		x				
Spinovina distributa Coryell and Malkin	x	x							x				x
Tetradella cicatricosa Warthin	x	x											
Ulrichia conradi Jones							x				x		
Ulrichia fragilis var. subnodata n. var.			x										

TABLE II: Occurrence of same Species in Related Areas

Species from Ontario Oil Wells	Silica Shale Ohio	Bell Shale Michigan	Traverse Group Michigan	Widder Beds Ontario
Amphissites parallela (Ulrich)				
Amphissites subquadrata (Ulrich)	x	x	x	
Boursella trilobata, n. gen., n. sp.				
Bufina lineata, n. sp.				
Dizygopleura euglyphea Warthin			x	
Dizygopleura trisinuata Van Pelt	x	x	x	
Dizygopleura sculptura, n. sp.				
Entomis, sp.				
Euglyphella sigmoidalis Jones	x	x	x	x
Eukloedinella doverensis, n. sp.	x			
Halliella bellipuncta (Van Pelt)	x	x	x	
Haploprimitia punctata, n. sp.				
Hollinella granifera (Ulrich)				
Hollinella subcircularis, n. sp.				
Hollinella, sp.				
Jenningsina concentrica, n. sp.				
Lucasella mundula Stewart	x			
Menoeidina arcuata, n. sp.				
Menoeidina subreniformis Stewart	x			
Octonaria cf. crescentiformis Van Pelt		x	x	
Octonaria quadricostata Van Pelt	x	x	x	
Poloniella cingulata Warthin	x		x	
Ponderodictya punctulifera (Hall)	x	x	x	x
Ponderodictya ohioensis (Stewart)	x			
Quasillites fordei, var. minimus, n. var.				
Quasillites reticulata, n. sp.				
Quasillites obliquus Coryell and Malkin				x
Spinovina distributa Coryell and Malkin				x
Tetradella cicatricosa Warthin	x		x	
Ulrichia conradi Jones	x		x	x
Ulrichia fragilis, var. subnodata, n. var.				

The ostracodes herein considered are the first in this facies to be described from below the surface; the collections in the related areas were made from surface exposures.

DESCRIPTION OF NEW SPECIES
AND
DISCUSSIONS ON PREVIOUSLY DESCRIBED FORMS

Superfamily **BEYRICHIACEA**
Family **PRIMITIIDÆ** Ulrich and Bassler
Genus **HAPLOPRIMITIA** Ulrich and Bassler, 1923
(Maryland Geol. Surv., Silurian, 1923, p. 297)

Haploprimitia punctata, n. sp. Plate 1, fig. 1

The carapace is minute, tumid; the outline is suboval. The ratio of length to height is 1.5 to 1. The valves are convex with the greatest convexity in the posterior half. The dorsal margin is straight, equal to three-quarters of the length of the carapace; a shallow channel in the posterior two-thirds indicates the hinge. The cardinal angles are obtuse, the posterior is the more acute, approaching 90° in some specimens. The posterior margin is broadly and evenly rounded, the anterior margin is narrowly rounded. The ventral margin is convex, rising to the anterior.

The surface of the valves rises abruptly from the posterior margin, the slope is steeply concave and inclined towards the anterior, leaving a narrow flattened rim around that margin. The slope to the other margins is rounded.

The greatest length of an average specimen, measured midway between the dorsal and ventral margins is 0.45 mm., the greatest height measured in the posterior half is 0.29 mm., the greatest thickness measured in the posterior half is 0.25 mm.

Anterior to the centre of each valve a well defined sulcus extends from below the dorsal margin halfway to the ventral margin.

The ventral extremity of the sulcus is umbilicate.

The surface of well preserved specimens is distinctly but not profusely punctate.

Remarks.—*Haploprimitia simplex* Stewart is a related form. In *H. punctata* the ventral margin rises more definitely towards the anterior; the sulcus is broad and well defined and terminates directly below the dorsal margin, whereas in *H. simplex* the sulcus is a linear slit. The punctate surface serves as a further distinction between the two species.

Holotype.—Collections of Geological Survey of Canada, Ottawa, No. 9395.

Genus **ULRICHIA** Jones, 1890
(Quart. Jour. Geol. Soc. London, vol. 46, 1890, p. 543)

Ulrichia fragilis Warthin, var. **subnodata**, n. var. Plate 1, fig. 2

Ulrichia fragilis Warthin, 1934, Mus. Pal. Univ. Mich., Contr., 4, No. 12, p. 21, pl. 1, fig. 11.

Warthin's description of *Ulrichia fragilis* is as follows:—

> Carapace semiovate in lateral view, with pronounced backward swing; greatest height just posterior to the center; anterior end much sharper and higher than the posterior; hinge line straight, four-fifths of the total length; false border around the free margins delineated by a thin carina which is strongest ventrally; the carina describes a nearly perfect semicircle, cutting across the anterior portion about one sixth of the length from the end; tubercles blunt, short, converging towards the dorsal margin, where they barely project above the hinge line; kirkbyan pit twice the size of the reticulation pits, located on the antero-ventral slope of the posterior tubercle; surface of the valves within the false border finely reticulated. Length, 0.53 mm., beight, 0.33 mm.

The description of *Ulrichia fragilis*, var. *subnodata*, n. var., follows:—

The carapace is subquadrate in laterial view. The valves are flat, with a slight convexity in the posterior half. The ratio of length to height is more than 2 to 1.

The dorsal margin is straight, equal to four-fifths of the entire length of the carapace. The cardinal angles are obtuse, the anterior is the more acute. The posterior margin is rounded, more protuberant immediately below the mid-line. The anterior margin is straight in the dorsal half, rounded, and more protuberant in the ventral half. The ventral margin is convex, rising towards the anterior.

The greatest length measured slightly below the mid-line is

0 5 mm., the greatest height measured in the posterior half is 0.27 mm. There is a marked difference in height between the posterior and anterior extremities.

A high, narrow ridge parallels the posterior and ventral margins but anteriorly it rises abruptly to the dorsal margin, leaving a wider marginal border in the antero-ventral region.

There are two, low, blunt nodes situated in the dorsal posterior two-thirds of each valve. The sulcus between them is shallow. The anterior node extends to the dorsal margin, the posterior is smaller and does not reach the dorsal margin.

The surface within the bordering ridge is coarsely pitted.

Remarks.—Three specimens of this species were available for study. As compared with Warthin's species, their outline is much more angular; the narrow ridge or carina which defines the false border is subsemicircular rather than semicircular, and the nodes are unequal and much lower.

Specimens of the typical *U. fragilis* were found in the surface collections from Thedford, Ontario and used for purposes of comparison. The specimens placed in *U. fragilis subnodata* are quite distinct from *U. fragilis* but the differences are not considered to be sufficient to separate them entirely from that species.

Holotype.—Collections of Geological Survey of Canada Ottawa, No. 9396.

Genus **HALLIELLA** Ulrich, 1891

(Cincinnati Soc. Nat. His., Jour., 13, pt. 2, 1891, p. 184)

Halliella bellipuncta (VanPelt) Plate 1, fig. 3

Amphissites bellipunctus VanPelt, 1933, Jour. Pal., vol. 7, No. 3, p. 332, pl. 39, figs. 37-40.

Halliella bellipuncta Warthin, 1934, Mus. Pal. Univ. Mich., Contr., vol. 4, No. 12, p. 208, pl. 1, fig. 2.

A single valve represents *Halliella bellipuncta* in this collection. It agrees remarkably well in every detail with the description of the type species given by VanPelt.

This species resembles very closely *Kirkbyella typa,* a Pennsylvanian form described by Coryell and Booth (9), from the Wayland shale, Texas, and for which the genus *Kirkbyella* was erected. A Devonian species *K. unicornis* Coryell and Malkin (10), has also been described. This latter species bears some resemblance to *H. bellipuncta.* Each of these three species has the typical umbilicate sulcus extending from the dorsal margin halfway to the ventral margin, the raised ridge terminating in a blunt node in the ventral half of each valve, and the strongly reticulated surface. The generic description of *Kirkbyella* mentions the unornamented marginal rim or ridge found, also, in *H. bellipuncta. H. bellipuncta* has been described from the Silica shale (11), Ohio; the figure given is strikingly similar to that given by Coryell and Booth for *K. typa.*

The three species, *K. typa, K. unicornis* and *H. bellipuncta* appear to be congeneric. If such is the case, the genus *Halliella* would be adequate for the reception of all of these species.

These observations are based entirely on comparison of the descriptions and figures of the various species and specimens in this collection. Several complete specimens from the surface collections were also used.

With regard to the orientation of *Halliella bellipuncta* Warthin, in placing *H. bellipuncta* in the genus *Halliella,* followed the original orientation as given by Ulrich, that is, he considered the sulcus to be posterior to the centre. VanPelt considered the sulcus to be anterior to the centre, which results in an opposite orientation. In the opinion of the writer, there is no distinctive character in the general shape of the carapace that warrants the correct orientation.

Family **BEYRICHIIDÆ** Jones

Genus **BOURSELLA,** n. gen.

The carapace is minute, subsemicircular to subquadrate in lateral outline. The valves are convex. The thickness of the valves increases rapidly from ventral to dorsal margin, giving a wedge-shaped appearance in ventral view. The dorsal margin is straight, the valves are distinctly trilobate dorsally, the lobes being confluent ventrally with the general surface of the valves. The median lobe is the largest and projects obliquely beyond the dorsal margin. The nodes or lobes are separated by well defined sulci.

The valves are subequal, the presence of a narrow overlap of the right valve on the left along the free margins is doubtful.

The surface is granular.

The following species, *B. trilobata,* n. sp., becomes the genotype for this newly erected genus.

Boursella trilobata, n. sp. Plate 1, fig. 4

The carapace is minute and subsemicircular to subquadrate in lateral outline. The valves are convex, increasing in convexity in the dorsal half. The ratio of length to height is slightly more than 2 to 1.

The dorsal margin is straight, equal in length to three-fifths of the greatest length of the carapace. The cardinal angles are subequally obtuse. The posterior margin is broadly and evenly rounded, the anterior more narrowly rounded. The ventral margin is convex, rising towards the anterior.

The maximum length of an average specimen measured midway between dorsal and ventral margins, is 0.4 mm.; the height measured in the posterior half is 0.25 mm.; the thickness increases from ventral to dorsal margin, where it measures 0.11 mm.

The right valve appears to be very slightly larger than the left in some specimens, in which the right valve curves over the left on the free margins. The presence of a true overlap is doubtful.

The hinge occupies the whole length of the dorsal margin.

Each valve is distinctly trilobate in the dorsal half. Ventrally the lobes are confluent with the general surface of the valve. The median lobe is the largest, and forms a spinelike projection beyond the dorsal margin. It curves obliquely towards the posterior. The posterior lobe projects slightly beyond the dorsal margin, and is partially divided again by a very shallow sulcus. The anterior lobe does not extend to the dorsal margin, but is quite distinct and is also inclined towards the posterior.

The posterior sulcus is broad and extends from the dorsal margin halfway to the ventral. It maintains a uniform width and has a squarish ventral termination with a slight curve posteriorly in certain specimens. The median sulcus is narrower and more elongate than the posterior. It extends two-thirds of the distance to the ventral margin. Ventrally, it becomes a shallow depression which curves posteriorly. This sulcus defines the median lobe anteriorly and gives the effect of obscurely yoking it with the posterior lobe, thus setting the posterior and median lobes apart from the anterior lobe.

The surface of the valves is quite distinctly granulose.

Remarks.—The strong, spinelike, median dorsal lobe in this new genus immediately suggests an Aechminidlike ostracode. The two smaller lobes, however, separated from the larger one by definite sulci, gives a trilobate effect. The presence of the three lobes has been a determining factor in placing this genus in the family Beyrichiidæ. A number of specimens were sent to Dr. F. M. Swartz*, who also noted the Aechminid resemblance; furthermore, he suggested that the obscure yoking of the posterior and median lobes might indicate affinities with the genus *Bollia.* Additional species in future studies may show more definitely the relationships of the genus.

A Pennsylvanian genus *Aechminella* Harlton (12), is closest to this form. Though it is much larger than this species, three dorsal spines or nodes are present. *Aechminella,* also, has an Aechminid appearance as would be indicated by the name. It is classified in the family Beyrichiidæ.

Boursella trilobata is a distinct little form which will not be confused with any of the typical Devonian ostracodes. The small size is a constant feature and diagnostic in itself. The species is not uncommon in the well cuttings.

Genoholotype.—Collections of the Geological Survey of Canada, Ottawa, No. 9397.

Genus **HOLLINELLA** Coryell, 1928
(Emen. Kellett, 1929)

(Coryell, Jour. Pal., vol. 2, No. 4, 1928, p. 377-378
Kellett, Jour. Pal., vol. 3, No. 2, 1929, p. 196-200)

Hollinella granifera (Ulrich) Plate 1, fig. 19

Bollia granifera Ulrich, 1891, Cincinnati Soc. Nat. Hist., Jour., 13, p. 205, pl. 12, figs. 12a, 12b.

Hollina granifera Ulrich and Bassler, 1908, U. S. Nat. Mus., Pr., 35, p. 315, pl. 42, figs. 16, 17.

Hollinella granifera Bassler and Kellett, 1934, Bibliographic Index of Pal., Ostracoda, p. 332.

An emended description of the species is given.

The carapace is elongate, ovate, tapering towards the anterior end. The ratio of greatest length to greatest height, including the frill is 1.7 to 1.

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* Pennsylvanian State College.

The dorsal margin is straight, the length slightly less than that of the carapace. The cardinal angles are subequally obtuse. The anterior margin is straight in the dorsal half, with a pronounced ventral backward swing. The posterior margin is straight in the dorsal two-thirds, rounding ventrally into the very convex ventral margin.

The maximum length measured ventral to the mid-line is 1.3 mm.; the height measured in the posterior half is 0.85 mm., including the frill. The height decreases rapidly in the anterior half of the carapace. The thickness is 0.55 mm. measured slightly anterior to the centre.

The articulation of the free margins and the hinge appear to be characteristic of the genus, that is, the left valve fits into a groove in the free margins of the right valve; along the hinge, the left valve receives the right, except at the cardinal extremities, where the right valve overlaps the left.

The frill extends from a short distance below and in front of the posterior dorsal angle, parallels the posterior and ventral margins and terminates at a point below the anterior extremity of the anterior dorsal node.

The surface is marked with a deeply impressed sulcus, situated posterior to the centre, and extending from the dorsal margin to below the mid-line. From this point it becomes a posteriorly directed, shallow depression, extending almost to the frill. Anteriorly the sulcus is bounded by a prominent hemispherical node which rises well above the surface. It projects beyond the dorsal margin and is separated from the low swelling ventral to it by a sharp sulcus. A small lobe is situated on the lower part of the posterior margin of the sulcus. Ventrally this lobe is confluent with the general surface of the valve. The surface of the valves anterior to the prominent anterior node is gently convex, the surface at the posterior extremity is flat and continuous with the frill.

The entire surface is coarsely granular.

Remarks.—A single specimen of this species was found. The genus *Hollinella* is not of common occurrence in the Devonian faunas, and has not been recorded from any of the related areas considered in this study.

This specimen differs in several minor aspects from the type species; the frill is more extensive postdorsally and is not as wide, and the anterior node does not appear to be quite as prominent. *H. granifera,* however, seems to be the appropriate species in which to place this specimen.

Hollinella subcircularis, n. sp. Plate 1, fig. 20

The carapace is elongate, rectangular in outline. The ratio of the greatest length to greatest height is 1 to 2.

The dorsal margin is straight, almost equal to the entire length of the carapace. The anterior cardinal angle is acute, approximately 90°; the posterior cardinal angle is slightly obtuse. The anterior margin is vertical in the dorsal two-thirds, curving strongly into the convex ventral margin. The posterior margin is broadly and evenly rounded.

The greatest length of the carapace measured midway between the dorsal and ventral margins, is 1.2 mm., the height, including the frill, is 0.65 mm., in the middle of the posterior half. There is a slight decrease in height anteriorly. The valves are moderately convex. The greatest thickness is in the ventral half, slightly posterior to the centre. The right valve is larger than the left, the margin being apparently grooved for the reception of the smaller valve on the free margins. This contact margin is finely denticulate. At the cardinal angles, the right valve overlaps the left valve.

The marginal frill extends from the postdorsal margin, parallel to the posterior and ventral margins, rising towards the anterior, where it terminates one-sixth of the length of the valve from the anterior margin. The frill is finely crenulated.

A deep median sulcus extends from the dorsal margin to below the mid-line. At its ventral extremity, the sulcus expands anteriorly and posteriorly, forming an inverted T-shaped depression. The surface of the valves rises in a U-shaped ridge above the sulcus. The ridge terminates anteriorly in a large bulbous node which extends to the dorsal margin. It is separated ventrally from the ridge by a narrow depression. The ridge terminates posteriorly in a small, elongate node, situated well below the dorsal margin. This node is also separated from the ridge by a shallow depression. The ridge rises steeply from the frill.

The surface at the anterior extremity of the valves is flat and low.

The entire surface, including frill and sulcus, is finely granulose. Along the posterior quarter of the dorsal margin, four distinct spines project beyond the edge of each valve. A number of similar spines are situated in a corresponding anterior position, and occur sparsely over the general surface.

This frilled specimen is a female of the species. A small specimen without a frill and with a similar shape and arrangement of lobes and sulci, is also placed in this species. It is regarded as a young specimen. The length of this specimen is 0.87 mm., the height is 0.43 mm. The surface is very finely granulose and bears no spines.

Remarks.—The identification of this species is based on the two specimens described, but the shape and extent of the sulcus, the subsemicircular shape of the carapace, the distinct ventral slope of the U-shaped ridge, and the spines along the dorsal margin, distinguish it from any of the described Devonian species. *Hollinella subcircularis* bears a closer resemblance to certain Pennsylvanian and Permian species than to any of the earlier Palæozoic forms.

Holotype.—Collections of the Geological Survey of Canada, Ottawa, No. 9398.

Hollinella, sp. Plate 1, fig. 17

A single specimen with the characteristic features of *Hollinella* is placed in this genus. Two features distinguish it from the other specimens in this collection, namely, the abrupt linearlike depression of the sulcus and the presence of two spines on each valve in anterior and posterior ventral positions on a line along which a frill would arise. These spines or nodes are thought to be an incipient frill, in which case, the specimen would be a young female.

Although several additional specimens were found in the surface collections which showed the above-mentioned features the relationships of the form are not sufficiently clear to warrant a specific identification. Additional material, including the frilled variety, would be necessary in order to determine the species.

Family **KLOEDINELLIDÆ** Ulrich and Bassler

Genus **DIZYGOPLEURA** Ulrich and Bassler

(Maryland Geol. Surv., Silurian, 1923, p. 213)

Dizygopleura sculptura, n. sp. Plate 1, fig. 6

The carapace is ovate, subquadrate in lateral outline. The valves are convex, the convexity increasing towards the anterior.

The dorsal margin is irregular, rising towards the posterior, where the right valve extends over the left as a narrow flap. The posterior margin is broad and rounded, somewhat more extended dorsally. The anterior margin is truncate, almost straight. The ventral margin is slightly concave at the middle, rising anteriorly.

The greatest length, slightly dorsal to the mid-height in an average specimen, measures 0.5 mm.; the greatest height, measured at the posterior end of the hinge flap, is 0.3 mm. The right valve is the larger, overlapping the left on the free margins and at the posterior end of the dorsal margin.

The surface of each valve is highly sculptured. The posterior sulcus extends from below the hinge flap almost to the ventral margin, curving forward and tapering to a point. The median sulcus is wider than the posterior and continues from a short distance below the dorsal margin to below the mid-line. Ventrally it curves backward. The anterior sulcus begins farther below the dorsal margin than the median sulcus, curves anteriorly parallel to the anterior margin, then curves ventrally and posteriorly, almost meeting the posterior sulcus in some specimens.

The four lobes or ridges formed by the sulci are united ventrally, the two anterior ones unite dorsally, enclosing the dorsal end of the anterior sulcus, and forming a ridge which slopes steeply to the dorsal margin. The slope from the ridge to the anterior margin is concave. There is a tendency, also, for the two posterior lobes to be raised dorsally above the general surface. The slope from the posterior lobe to the margin is rounded and less abrupt than the corresponding anterior slope.

Remarks.—This species most closely resembles *D. minima* Ulrich and Bassler (13), a Silurian species in which the anterior lobes are confluent dorsally. These Devonian specimens are larger than *D. minima* and differ, also, in that the posterior and anterior sulci curve towards each other ventrally, and in some specimens almost unite. All the surface features appear to be more highly developed and more clearly defined in this newly described species. It may be distinguished from other Devonian species by its shape, and by the arrangement of the anterior lobes and sulcus.

Holotype.—Collections of the Geological Survey of Canada, Ottawa, No. 9399.

Genus **EUKLOEDENELLA** Ulrich and Bassler
(Maryland Geol. Surv., Silurian, 1923, p. 313)

Eukloedenella doverensis, n. sp. Plate 1, figs. 5, 8

Eukloedenella, sp., Stewart, 1936, Jour. Pal., vol. 10, No. 8, p. 750, pl. 100, fig. 28.

The carapace is comparatively large, with a smooth surface and subquadrate outline. The valves are convex, somewhat flattened posteriorly, and thickened anteriorly.

The dorsal margin is straight, channelled in the anterior half for the hinge. The cardinal extremities are obtuse, the posterior cardinal slope being longer and more obtuse than the anterior. The posterior margin is broadly rounded ventrally. The anterior margin is blunt with a backward swing. The ventral margin is straight, rising slightly to the posterior.

The greatest length measured at mid-height is 0.9 mm., the greatest height is in the anterior half and equal to 0.49 mm., the thickness, also, in the anterior half is 0.3 mm.

A simple umbilicate sulcus on each valve posterior to the centre extends from the dorsal margin slightly less than halfway to the ventral margins. The left valve appears to be larger than the right, but the valves are not in contact along the free margins, and the relative size cannot be definitely determined.

Remarks.—A single complete and well preserved specimen of this species was found. Stewart recorded and figured an incomplete specimen from the Silica shale, Ohio, which appears to be the same as this specimen. The specimens most closely resemble the Silurian species *E. umbilicata* Ulrich and Bassler, which is the typical species in Group II of the genus *Eukloedenella* as outlined by them, and to which Stewart referred her specimen.

E. richmondensis Spivey (14), recently described from a single specimen in the Maquoketa shale, Iowa (Ordovician), resembles this Devonian species in general outline, but, it is thicker posteriorly, whereas *E. doverensis* thickens anteriorly, and is a larger and more robust form. The sulcus is closer to the posterior margin in *E. richmondensis*.

Holotype.—Collections of Geological Survey of Canada, Ottawa, No. 9400.

Superfamily **CYPRIDACEA**

Family **THLIPSURIDÆ** Jones

Genus **BUFINA** Coryell, 1936

(Am. Mus. Nov., No. 891, Nov., 1936, p. 8)

Bufina lineata, n. sp. Plate 1, figs. 9, 12

The carapace is elongate, the outline is subrectangular. The valves are tumid, thick, and flattened laterally. The dorsal margin is straight, rising towards the anterior and posterior; the intervening length is depressed.

The cardinal angles are obtuse, the anterior being the more acute. The posterior margin is rounded and more extended ventrally. Some specimens have small spinelike papillæ on the posterior-ventral border. The anterior margin is truncate, almost straight, swinging back into the ventral margin. The latter is slightly convex, rising towards the anterior.

The maximum length of the carapace is 0.81 mm., the height 0.34 mm., the thickness 0.28 mm. The valves are equal.

The surface of the valves is raised high above the contact margin, leaving a narrow flat border. Two prominent blunt spines, project obliquely forward from the anterior region of each valve. Posteriorly, the raised surface forms a thickened ridge which parallels the posterior margin. The surface anterior to the ridge is flattened, almost concave.

A strong series of fine linear ridges arranged in a subconcentric pattern, mark the entire surface, including the posterior ridge and the anterior spines.

Remarks.—This species is more elongate than *Bufina elongata* Coryell and Malkin (15). There is no marked variation in height between the anterior and posterior ends as in other species, and the general shape is more rectangular. The surface striations are typical of this new species. Stewart (16) described a related species, *Moorea bicornuta* Ulrich, from the Silica shale, Ohio.

Coryell included this latter species in his genus *Bufina.*

Holotype.—Collections of the Geological Survey of Canada, Ottawa, No. 9401.

Menoeidina arcuata, n. sp. Plate 1, figs. 11, 14

The carapace is elongate, arclike in outline. The ratio of length to height is 2.3 to 1. The valves are equally convex, somewhat flattened anteriorly. The thickness increases from posterior to anterior, giving a wedge-shaped appearance in dorsal view.

The dorsal margin is convex, with a long gradual posterior slope rising to the point of greatest convexity in the anterior half of the margin. The cardinal angles are obtusely rounded. The posterior margin is narrowly rounded; the anterior margin is blunt, almost straight without backward swing. The ventral margin is straight, with a slight concavity at mid-length.

The greatest length measured in the ventral half is 0.63 mm., the greatest height 0.27 mm., measured in the anterior half, the greatest thickness, also, in the anterior half, 0.25 mm.

The right valve overlaps the left very slightly posteriorly and ventrally.

The surface of the valves rises abruptly from the anterior end and forms a thickened ridge. Dorsally the ridge diminishes, ventrally it terminates in a short blunt spinelike projection.

A number (approximately 12 or 13) of relatively large, coarse, equally spaced pits or punctæ are arranged in a somewhat regular fashion on the surface of each valve, immediately posterior to the anterior ridge and not extending to the centre of the valve. The remainder of the surface is smooth. The pits are constant in their occurrence and striking in their restricted distribution.

Remarks.—*Menoeidina arcuata* is smaller and more elongate than *M. subreniformis* Stewart. The height increases from posterior to anterior, rather than from anterior to posterior, as in the latter species. The more restricted anterior ridge with the spinelike ventral termination and the strongly pitted anterior area serve to completely distinguish the two species. Although distinct specific differentiation is recognized, little hesitation is felt in referring these two forms to the same genus.

Holotype.—Collections of the Geological Survey of Canada, Ottawa, No. 9402.

Genus **PONDERODICTYA** Coryell and Malkin, 1936
(Am. Mus. Nov., No. 891, Nov., 1936, p. 15)

Ponderodictya punctulifera (Hall) Plate 1, fig. 7

Leperditia punctulifera Hall, 1860, N. Y. State Cab., 13th Ann. Rep., p. 92,

Primitiopsis punctulifera Jones, 1890, Geol. Soc. London, Quart. Jour., vol. 46, p. 9, pl. 2, figs. 7, 12, 13.

Cytherella ? bispinulatus Stewart, 1927, Ohio Geol. Surv., 4th ser., Bull. 32, p. 60, pl. 5, figs. 18, 19.

Primitiopsis unicornis VanPelt, 1933, Jour. Pal., vol. 7, p. 326, pl. 59, figs. 23-28.

Cytherellina punctulifera Warthin, 1934, Mus. Pal., Univ. Mich. Contr., vol. 4, No. 2, pp. 222, 223, pl. 1, figs. 24, 25.

Ponderodictya bispinulata Coryell and Malkin, Nov. 1936, Am. Mus. Nov., No. 891, p. 15, figs. 28, 28a, 29, 30.

Hamiltonella punctulifera Stewart, 1936, Jour. Pal., vol. 10, No. 8, p. 756, pl. 102, figs. 1-5.

Ponderodictya punctulifera (Hall) is the most abundant and characteristic species of this ostracode fauna. In this area, as in each of the areas from which it has been described, the species shows great variety of form and surface markings. The large collection of specimens from these well samples has been studied with a view to determining whether the variations in size, shape, and surface markings were sufficiently constant to constitute distinct species or varieties. As a result of this examination, three more or less distinct types have been recognized.

Type I is represented by large, convex, subreniform specimens with two prominent posterior spines and an anterior tubercle on each valve. The surface is coarsely reticulate. In general, all the surface features are more strongly developed on the right valve than on the left, although in certain specimens the anterior tubercle only, is weak on the left valve. The typical shape in this group is subovoid with the height slightly more than half the length. Other forms are more elongate, while a third variety, distinctly ovoid in outline, is more obese.

A similar type has been described from the Silica shale, Ohio.

Type II has the ventral posterior spine only, developed on each valve. The anterior tubercle shows a weaker development on both valves and, in some instances, it is entirely lacking on the left valve. Variations in the ratio of height to length and in the relative convexity of the carapaces, similar to those described in the first type, are also present here.

This second type corresponds closely to one described from the Silica shale. The latter, however, shows no anterior tubercle developed on the left valve.

Type III has the posterior spines and anterior tubercle developed on the right valve, but they are completely absent from the left valve. The reticulations on the left valve of some specimens are indistinct, especially towards the margins, where they have the appearance of being worn. Weathering of specimen before fossilization, may account for the lack of surface characters in some cases. In spite of this fact, however, other specimens do appear with well marked reticulations and no nodes on the left valve.

In addition to the above types, a number of small, subquadrangular specimens with coarse reticulations and well developed spines and tubercles have been observed. These were at first considered to form a distinct variety, but on considering the species as a whole, they appear to be individual variations, probably small sized mature forms.

An attempt was made to use these so-called varietal types as detailed zone markers, but the results proved unsatisfactory.

The study of this large collection of specimens of the species *Ponderodictya punctulifera,* has shown that differences which may appear of great significance when small collections are considered, are in reality merely developmental stages in the growth of the individuals of the species.

Certain variations, particularly those of size and convexity, are regarded as sex differences. The large more ovoid and more obese forms are considered to be the females of the species.

The state of preservation undoubtedly accounts for many inconsistencies of shape and surface markings. Some specimens are internal casts and lack surface reticulations. As pointed out, in the third type, the smooth surface with indistinct markings may have been produced by weathering before burial of the specimens was effected. The left valve commonly shows the worn appearance; since it is the larger valve and overlaps the right on all margins, it would of necessity be more exposed.

Genus SPINOVINA Coryell and Malkin, 1936
(Am. Mus. Nov., No. 891, Nov. 1936)

Spinovina distributa Coryell and Malkin

Spinovina distributa Coryell and Malkin, Nov. 1936, Am. Mus. Nov., No. 891, p. 17, fig. 37.

A number of specimens have been isolated from those referred to the genus *Quasillites* because of their more ovate outline and more prominent surface ridges. These specimens are also more tumid than the typical *Quasillites.* They resemble *Spinovina distributa* more closely than any of the species of *Quasillites.*

The distinction between these specimens and those placed in *Quasillites* is not very striking. One of the distinguishing features of *Spinovina,* as indicated by Coryell and Malkin, is the deep sulcus on the dorsal margin. The specimens of *Quasillites,* however, in this collection have equally well developed sulci on the dorsal margin. Both genera have the typical ridged surface, anterior spine and posterior crest. The differentiation of the two genera is not very clear; *Spinovina,* as at present defined, might easily be regarded as a species of *Quasillites.*

Genus QUASILLITES Coryell and Malkin, 1936
(Am. Mus. Nov., No. 891, Nov. 1936, p. 18)

Quasillites oliquus Coryell and Malkin Plate 1, figs. 15, 18

Quasillites obliquus Coryell and Malkin, Nov. 1936, Am. Mus. Nov., No. 891, p. 18, figs. 36, 36a.

Coryell and Malkin's description of this species is as follows:—

> Carapace oblique rhomboidal; hinge line straight, partly covered by the overlap of the right valve in the posterior portion. Cardinal angles obtuse, the posterior larger than the anterior. Ventral margin straight, with broadly curved extremities. Anterior end narrowly rounded in the upper half, with an oblique backward swing in the lower half; posterior end narrowly curved in the lower half, and truncated dorsally. Surface marked by faint longitudinal lines typical of the genus, bifurcating from a median line along the crest of the convexity and diverging anteriorly. A very insignificant posterior ridge is present at the crest of the short steep posterior slope of the surface of the valve; a prominent antero-ventral spine projects forward from the crest of the slope where the convexity of the valve dips steeply to the anterior margin. A less ornamented median area is present near the centre of each valve. Right valve, overlaps the left on free margins and on part of dorsal margin; right valve is grooved to receive the free margins of the left valve. Greatest convexity is located near the centre of the anterior half; height practically uniform throughout; dorsal and ventral margins are parallel.
>
> Length.—1.10 mm. Height.—0.55 mm.

Remarks.—The specimens placed in this species correspond to the above description in every respect, except for a distinctly channelled hinge in the anterior two-thirds of the dorsal margin, and a flattening of the valves in the posterior dorsal region. These differences are not sufficient to warrant a separation from the type species.

In addition to the large typical forms, there are numerous specimens which are small and more convex. The posterior ventral region is less protuberant and the anterior margin is more truncate. In other respects they resemble the larger form, and are readily recognized as belonging to this species.

Some typical specimens of this species were sent to Dr. Coryell at Columbia University for examination. In a personal communication, he suggested that they represented a new species owing to their more rectangular shape. This second group as outlined above might form a new species, but in the opinion of the writer, such a division of these forms is not warranted.

Quasillites reticulata, n. sp. Plate 1, fig. 10

The carapace is elongate-ovate with moderate convexity. The ratio of height to length is 1 to 2.

The dorsal margin is slightly convex, with a very narrow sulcus in the anterior two-thirds. The cardinal extremities are obtuse, the posterior flattened and elongate, the anterior rounded. The posterior margin is rounded with the border widened and finely crenulated in the post ventral part; the anterior margin has a slight ventral backward swing. The ventral margin is straight or slightly convex.

The greatest length, measured slightly above the mid-line is 0.60 mm., the height 0.30 mm., the thickness 0.20 mm. in the anterior half. The right valve overlaps the left ventrally and anteriorly.

A minute spine projects forward from the antero-ventral region. The surface of the valves rises steeply from the anterior and posterior margins. The linear markings are very fine and are united by fine crossbars, which produce a reticulate appearance. The linear ridges diverge from the smooth central unornamented spot.

Remarks.—This species differs from the other species of *Quasillites* in its smaller size and more ovate outline. It lacks the strong posterior-ventral swing of *Q. obliquus.* The crenulations on the postventral margin and the fine reticulate markings serve as further distinctions.

Holotype.—Collections of the Geological Survey of Canada, Ottawa, No. 9403.

Quasillites fordei Coryell and Malkin, var. **minimus**, n. var. Plate 1, fig. 13

Quasillites fordei Coryell and Malkin, Nov. 1936, Am. Mus. Nov., No. 891, p. 18, fig. 38.

The description of the type species is as follows:—

Carapace sub-oblong; hinge line straight; ventral margin straight except where it curves to meet the rounded ends of the valves; anterior end almost straight, with backward swing, height about two-thirds as great as the posterior end; anterior cardinal angle slightly obtuse; posterior cardinal angle greater than anterior; greatest extension of posterior margin is near ventral edge. Surface of valves is covered by fine ridges, an outer set paralleling the outer margins of the valve, and the two inner sets each roughly concentric in the anterior and posterior halves of the valve and converging towards an indefinite transverse cincture which extends from the dorsal to the ventral margin a little posterior to the centre of the valve. The fine ridges are connected, rarely, by very thin dissepiment-like cross-bars. A poorly defined central spot is present. A small spine projects forward from the antero-ventral region, close to the margin. Surface of valves slopes very gradually to the anterior edge; the posterior surface is slightly more convex than the surface of the anterior half, and the slope to the posterior margin is more abrupt with a slight swelling at the crest of this slope. Greatest height is located about one-fourth of the length from the posterior margin.

Length.—0.68 mm. Height.—0.40 mm.

Quasillites fordei, var. *minimus* is small, elongate, and subquadrate. The ratio of height to length is somewhat more than 1 to 2. The valves increase in height in the posterior half.

The dorsal margin is straight, in some specimens slightly convex, rising at the posterior end. There is a distinct sulcus in the anterior two-thirds. The cardinal angles are obtuse and evenly rounded, the anterior is slightly less obtuse than the posterior. The posterior margin is broadly and evenly rounded; the anterior margin is almost straight with a slight backward swing. The ventral margin is straight. The posterior contact margin is somewhat wider than the anterior and finely crenulated in some specimens.

The valves measure 0.61 mm. in length slightly below the midline, 0.27 mm. in height in the posterior half, decreasing by one-third of this in the anterior half. The right valve overlaps the left on the ventral margin and to a lesser extent on the ends.

There is a small sharp spine in the anterior-ventral region. The surface has strong linear markings arranged in a subconcentric manner.

Remarks.—This variety of *Quasillites fordei* differs from the type species in the presence of the sulcus on the dorsal margin, and lacks the abrupt slope to the posterior margin, the valves being more uniformly convex.

Holotype.—Collections of the Geological Survey of Canada, Ottawa, No. 9404.

Genus **JENNINGSINA** Coryell and Malkin, 1936
(Am. Mus. Nov., No. 891, Nov. 1936, p. 19)

Jenningsina concentrica, n. sp. Plate 1, fig. 16

The carapace is subrectangular to subrhomboidal in outline. The valves are flattened laterally. The ratio of length to height is slightly more than 2 to 1.

The dorsal margin is straight, rising at the posterior and anterior extremities where the marginal rim extends around the cardinal angles. The latter are obtuse, the posterior being the more obtuse. The posterior margin is broadly rounded, more protuberant in the ventral half; the anterior margin is truncate, almost straight, with a backward swing in the ventral part. The ventral margin is straight, with a slight central sinuosity.

The specimens have an average maximum length at mid-height of approximately 0.62 mm., the height varies considerably among them, averaging from 0.25 mm. to 0.32 mm. The height in all forms decreases anteriorly. The right valve overlaps the left on the free margins, the overlap being greatest in the centre of the ventral margin.

The surface of the valves rises steeply from the anterior margin leaving a narrow marginal rim which continues along the anterior ventral and dorsal margins short distances. Posteriorly, the rise is less abrupt, but the marginal rim is wider and extends up around the post-dorsal margin, and also, continues ventrally along the ventral margin one-third of its length. A number of minute papillæ project beyond the edge of the posterior marginal rim in the ventral half.

On both valves a sharp spine projects obliquely forward from the antero-ventral region. There is a small blunt spine or node in a corresponding dorsal position in some specimens.

On the surface of each valve a series of subconcentric ridges, which begin in a triangular pattern in the anterior half of the carapace, gradually enlarge to encircle the whole surface. The ridges are connected with crossbars at intervals slightly longer than the distance between the ridges, making series of elongate reticulations. Towards the margins, the ridges are closer together and there are no crossbars developed.

Remarks.—This species differs from *J. catenulata* (VanPelt), in the more elongate shape and subrhomboidal outline. The anterior dorsal and posterior ventral regions are more protuberant in *J. concentrica,* while in the other species, both margins are protuberant ventrally.

The surface ridges are distinctive in their concentric pattern, which results in the ridges forming parallel lines around the margins. In *J. catenulata* they diverge from a median line.

VanPelt's specimens are described as having anterior nodes or spines similar to those in *J. concentrica,* but Coryell neither describes nor figures these structures.

Holotype.—Collections of the Geological Survey of Canada, Ottawa, No. 9405.

SUMMARY AND CONCLUSIONS

As a result of this investigation, it has been shown that the majority of the ostracodes from the well cuttings are typical Middle Devonian forms. Some species, however, *e. g. Hollinella subcircularis,* n. sp., have Pennsylvanian affinities, while others, *e. g. Eukloedinella doverensis,* n. sp., suggest certain Silurian species. Among the characteristic Middle Devonian species are: *Ponderodictya punctulifera* (Hall), *Dizygopleura trisinuata* Van Pelt, *Euglyphella sigmoidalis* (Jones), and *Amphissites subquadratus* (Ulrich).

Nine new species, two new varieties, and one new genus have been added to the rapidly growing list of Middle Devonian ostracodes. The genera *Lucasella* and *Menoeidina* are recorded for the first time outside of their type locality in the Silica shale, Ohio. Two other genera, *Quasillites* and *Spinovina,* described originally from the Widder beds, Ontario, are recorded only for the second time.

When this study was initiated, it was hoped that minor zones might be established within the Upper Ostracode zone, which could be effectively used in working out the stratigraphy. As the study proceeded, however, it did not seem possible to recognize such faunal units.

In the Silica shale, Ohio (17), certain species have been found to occur in abundance in the various lithological units. In the Traverse group of Michigan (18), a broader zoning of certain species has been recognized.

In the area under consideration well samples have been taken at regular intervals from approximately one hundred feet of the Hamilton shales. Through this thickness of strata the more abundant species are distributed quite uniformly. The rarer species, though they might seem to be confined, could scarcely be considered as zone markers since there is no uniformity in their order of appearance in the various wells.

The study of microfossils has been greatly accelerated within recent years, because of the important role they have played in the field of petroleum geology. The ostracodes are one of the most satisfactory groups of microörganisms to study on account of their diversity of form and their widespread occurrences both geographically and geologically. Since the ostracodes which have been discussed were obtained from the important oil and gas fields of southwestern Ontario the present study has a distinct economic bearing; an added significance is, therefore, given to this investigation.

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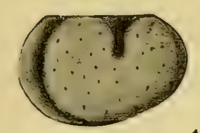
*(All specimens are magnified 40 diameters unless otherwise indicated)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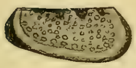
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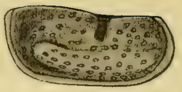
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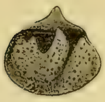
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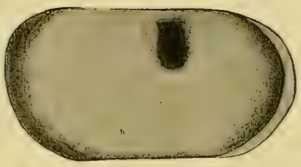
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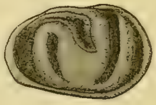
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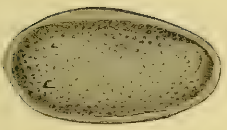
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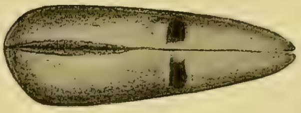
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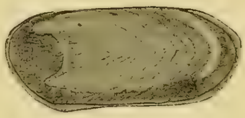
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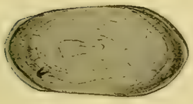
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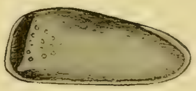
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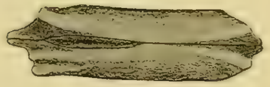
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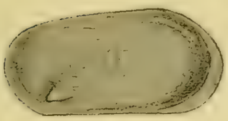
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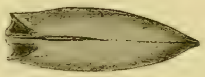
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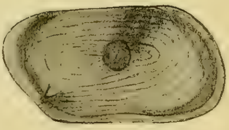
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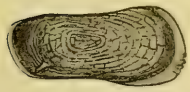
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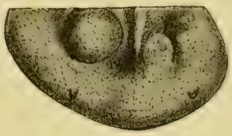
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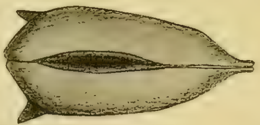
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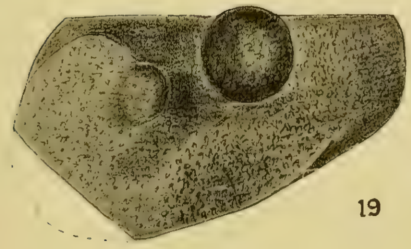
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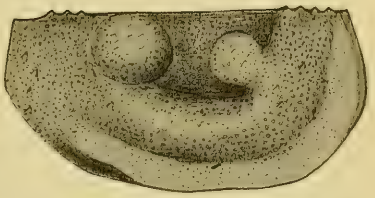
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Eight Species of Pennsylvanian Crinoids

By

HARRELL L. STRIMPLE

August 23, 1939

PALEONTOLOGICAL RESEARCH INSTITUTION
Ithaca, New York
U. S. A.

EIGHT SPECIES OF PENNSYLVANIAN CRINOIDS

By

HARRELL L. STRIMPLE

The original form described as *Cyathocrinus stillativus* White has never conformed with any known genus. *Whiteocrinus,* n. g. is herein proposed for its reception, and a new form *Whiteocrinus exsculptus,* n. sp., described thereunder. *Poteriocrinites ramonaënsis,* n. sp., is a form from near Ramona, Oklahoma, with which a new ontogenetic theory is proposed. From the Wewoka formation near Holdenville, Oklahoma now comes a form identical with, and presented as *Poteriocrinites magnus* Wright. Wright's specimens come from the Lower Limestone series of the Scottish Carboniferous, which is generally correlated with the Chester group, Upper Mississippian (Upper Carboniferous) of North America, whereas the specimens at hand are from the Middle Pennsylvanian (Upper Carboniferous). This occurrence then opens the possibility that the stratigraphic range of the Scottish Carboniferous might possibly extend into the North American Pennsylvanian period. At least there is room for conjecture. *Utharocrinus granulosus,* n. sp., is of particular interest since we have here the arms, tegmen, and growth stages.

In dealing with immature forms in Pennsylvanian strata we must proceed with rigid care, which is, however, to be tempered with sensible judgment. There are at hand two distinct small forms which are rather common in the locales under observations, yet large similar specimens have not been observed. If larger specimens are later found, yet the relationship with these small forms never established through lack of growth stages, there will be no great harm done since each form will serve its purpose as a distinct, determinable unit. It is to be noted that there are a few similar forms which have not been included since they have not been observed in complete enough preservation for accurate generic determinations. Those two under consideration are described herein as *Scytalocrinus deminutivus,* n. sp., and *Scytalocrinus larvalis,* n. sp.

AUG 29 1939

I am indebted to my wife, Mrs. Melba Strimple, for her usual good collecting and assistance, as all specimens herein figured were collected either by her, or the author, save those figured as *Poteriocrinites magnus* Wright which were collected by Mr. Audd Dailey of Holdenville, Oklahoma.

Order **INADUNATA** Wachsmuth and Springer

Suborder **FISTULATA** Wachsmuth and Springer

Family **CYATHOCRINIDÆ** Roemer

(Emend. Wachsmuth and Springer)

Genus **WHITEOCRINUS**, n. g.

Genotype.—*Whiteocrinus stillativus* (White).

White described an unusual form as *Cyathocrinus stillativus.* Wachsmuth and Springer (1886) listed the same under *Cyathocrinus* but noted that it probably belonged elsewhere. Keyes (1894) referred the same to *Phialocrinus,* whereas the form is quite distinct from any known genus.

Cup composed of five IBB, BB, and RR, with three anal plates; one hexagonal plate followed more or less evenly but two slightly smaller hexagonal plates, those later being within the cup mostly by virtue of the high articular facets of the RR; all plates of the cup strongly ornamented; the basal area depressed. The arms are known to branch once on the stout IBr^1; brachials rapidly becoming wider than high, pentagonal-shaped, interlocking, forming wide strap like biserial arms which exhibit a strong tendency to coil so that one frequently finds small portions in a tight roll. It is known that at least some plates of the tegmen are protruded as spines.

In addition to the genotype there are known *Whiteocrinus exsculptus,* n. sp., another species, figured herein as *Whiteocrinus,* sp. indet., and *Whiteocrinus angulatus*[1] (Miller and Gurley).

Occurrence and horizon.—Pennsylvanian (Upper Carboniferous); North America.

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[1] Miller, S. A., and Gurley, Wm. F. E.: *Description of some new species of Invertebrates from the Paleozoic rocks of Illinois and adjacent States* Illinois State Museum of Nat. Hist., Bull. No. 3, 1893, p. 59, pl. 6, fig. 9 (as *Aesiocrinus*).

Whiteocrinus stillativus (White) Plate 1, figs. 1, 2, 9

Cyathocrinus stillativus White, 1880, Proc. Nat. Mus., vol. II, p. 258; 1880, Geol. Surv. of the Territories, p. 125, pl. 35, figs. 3a, b.

Cyathocrinus (?) *stillativus* Wachsmuth and Springer, 1886, Revision of the Paleocrinidæ, Part 3; Proc. Acad. Nat. Sciences, Phila., p. 226.

Phialocrinus stillativus Keyes, 1894, Geol. Survey Missouri, vol. 4, p. 219, pl. 28, figs. 6a, b.

This species has been adequately described, and only certain points are especially brought out here. Just below the articular facets of the RR, two strong ridges pursue divergent courses to the lower extremity of the plate where they are matched by similar occurrences in the BB, as also the strong depressions about the raised area are confluent. The upper lateral extremities are slightly tumid but do not form strong ridges. This system of adjoining tumidity is also carried into the anal series of the cup. The lower portion of BB exhibits various specialized protuberances, normally a very sharp vertically developed ridge, after which there is a strong drop to the more or less flattened basal area, the same being occupied by the IBB.

The specimen with which we have knowledge of the arms of this species is unfortunately poorly preserved, nevertheless adequate for observation. The arms branch once on the rather low, wide IBr^1, following brachials rapidly becoming low symmetrical five sided interlocking plates, forming wide straplike biserial arms. There is a tendency for the outer portions of the arms to become slightly protuberant after which they curve strongly under.

The stem is composed of round, alternating, expanding, rather thin columnals, with strongly crenulated circumference, said crenulations being easily visible from side view, and pierced by minute round axial canal.

Of the tegmen it is known that some of the plates are protruded as spines.

Occurrence and horizon.—Stanton limestone member, Ochelata group, Pennsylvanian, the mound just west of the city limits of Bartlesville, Oklahoma.

Figured specimens.—Springer Collection of the U. S. National Museum.

Whiteocrinus exsculptus, n. sp. Plate 1, figs. 7, 8

This species is identical in general structure with *Whiteocrinus* *stillativus*, and *W. angulatus*, differing in ornamentation and subsequent tumidity of the plates, being therein quite distinct. The outer surface of RR are gently tumid as a whole, the only erratic development being just below the articular facet where two small sharp ridges are formed, following divergent courses to the lower portions of the plate, but not quite reaching the sutures, and not being matched by similar development on the BB. The lower portions of the BB are protruded, but rather regularly, so that a strong pentagon is formed when viewed from below, and the subsequent drop to the floor of the base is very gentle.

Cup 19.1 mm. wide by 9.3 mm. high.

Stem and tegmen unknown.

Occurrence and horizon.—Stanton limestone member, Ochelata group, Pennsylvania, the mound just west of the city limits of Bartlesville, Oklahoma.

Type.—Springer Collection of the U. S. National Museum.

Whiteocrinus, sp. indet. Plate 1, figs. 3, 4

This specimen is presented to give a more comprehensive conception of the arms of these forms. Please note that the arm shown to the extreme left in pl. 1, fig. 4, is the under side of that arm shown in pl. 1, fig. 3, also to the extreme left. The species is distinct from any known species in that an associated RR is found to have three sharp ridges pursuing divergent courses from just below the articular facet, one being interposed between the normal two. It is thought more fitting to wait for a more complete specimen before attempting to establish the species.

Occurrence and horizon.—Stanton limestone member, Ochelata group, Pennsylvanian, the mound just west of the city limits of Bartlesville, Oklahoma.

Figured specimen.—Springer Collection of the U. S. National Museum.

Family **POTERIOCRINITIDÆ** Bassler

Genus **POTERIOCRINITES** S. J. Miller

Presenting here under, *Poteriocrinites ramonaënsis*, n. sp., which is suggested to possibly represent a link with *Ethelocrinus* Kirk, exemplified by *E. plattsburgensis*[2] Strimple, and *E. con-* and elimination of the right tube plate, you have a form quite close to *E. convexus,* which is in turn very close to *E. plattsburgensis.* This theory is advanced only for those forms specifically mentioned, as there seems to be some differences within the *Ethelocrinus.*

Also presented as, and identical with, *Poteriocrinites magnus* Wright are some dissociated plates from near Holdenville, Oklahoma.

Poteriocrinites ramonaënsis, n. sp. Plate 1, figs. 5, 6

Calyx rather high, turbinate-shaped, diameter 20 mm., height 16 mm.; IBB 5 pentagonal plates easily visible from side view, rising directly from the round flat area occupied by the proximal columnal; BB 5 large, slightly tumid, very thin, hexagonal plates save that of the posterior which is truncated for the reception of the rather large anal X, and carries obliquely, together with the r. post. B, the large radianal; RR five, rather large, pentagonal elements, distal portions slightly constricted giving a swollen appearance, facets developed mildly as shelves, slanting inward, not quite filling face of RR, ligamental furrow to the fore adjoined by strong cross ridges, the muscle scars taking the form of shallow grooves centering at a shallow rounded depression in the median portion of the articular facet; anal series consisting of three large plates, anal X hexagonal, resting broadly on post. B, distal portion extended out of cup and curved strongly inward, radianal pentagonal, resting obliquely on post. B, supported by r. post. B, and supporting above the right tube plate, which is pentagonal with upper extremity extending out of cup, and followed by two azygous plates, that to the left being small and quadrangular.

Of the arms only the first few brachials of one ray are definitely known, ten cuneiform arms branching on IBr¹ are indicated. IBr¹ low, slightly constricted laterally, IIBr¹ rather squat, stout with strongly rounded back, and deeply notched by ambulacral groove.

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[2] Strimple, Harrell L.: *A group of crinoids from the Pennsylvanian of northeastern Oklahoma,* 1938, p. 10, pl. 2, figs. 6, 9, 12.

vexus[3] Strimple. By lowering the IBB disk of *P. ramonaënsis*

[3] Strimple, Harrell L.: *A group of Pennsylvanian crinoids from the vicinity of Bartlesville, Oklahoma,* Bull. Amer. Paleont., vol. 24, No. 87, 1939, p. 13, pl. 1, figs. 11, 12, 15, 16.

Round stem composed of alternating expanded columnals, minor crenulations about the edge, axial canal small and pentalobate.

Relationship.—This species is considered closely related to, and the possible predecessor of, *Ethelocrinus convexus.* The form is quite distinct from other known species of the genus.

Occurrence and horizon.—Stanton limestone member, Ochelata group, Pennsylvanian, the mound 3½ miles due west of Ramona, Oklahoma.

Type.—Springer Collection of the U. S. National Museum.

Poteriocrinites magnus Wright Plate 1, figs. 10-12

Poteriocrinites magnus Wright, 1937, Geol. Mag., vol. LXXIV, No. 879, p. 405, pl. 14, fig. 1.

Cursory examination proves the specimens at hand to be identical with *P. magnus.* Note especially the sharp, squared off lower extremity of the articular facet. As previously mentioned, Wright's specimens come from the Scottish Carboniferous, Lower Limestone series, whereas these specimens were collected by Mr. Audd Dailey of Holdenville, Oklahoma, from the Wewoka formation, Middle Pennsylvanian (Upper Carboniferous).

Figured specimens.—Springer Collection of the U. S. National Museum.

Genus **UTHAROCRINUS** Moore and Plummer

Utharocrinus granulosus, n. sp. Plate II, figs. 1-7

Crown of immature specimen measures 10.3 mm. to tip of arms; width of smallest observed calyx 3.4 mm.; height 2 mm.; normal calyx 10.5 mm. wide, by 4 mm. high.

Calyx flaring bowl-shaped; base depressed only in that the lower portions of BB are protruded; IBB disk flattened and occupied in the main by columnar scar, which is slightly depressed; IBB 5 small, pentagonal elements; BB 5 large hexagonal elements, save that the post. which is truncated for the reception of anal X, normally, lower portions are very tumid and possess a vertically developed, very thin, sharp, spinelike node in median section of plate; lower extremity curved under to form portion of the basal area; RR 5 pentagonal elements, tumid, articular shelves developed slightly outward; lateral extremities rather high, with strong notch at sutures; ambulacral groove strong; ligamental furrow to the fore sharp but not large; cross ridge rather prominent; muscle scars well developed as wide shallow depressions. Anal series within the cup normally three small, slightly elongated plates, very erratic placement. Under normal conditions the anal X is hexagonal, supported by the post. B, extending slightly out of cup; radianal pentagonal, resting on the post. B, supported by r. post. B, and in turn supports the small, hexagonal right tube plate. Specimens have been observed wherein the radianal is irregularly quadrangular, resting directly on post. B and supporting anal X above, the right tube plate having been entirely eliminated from the cup. Transitional stages between the extreme noted, and normal occurrence as described, have been observed.

The arms are ten in immaturity, branching once on IBr^1. In mature forms they are known to branch again on IIBr^4 or IIBr^5, and probably once more in some rays. Three, or more, small, sharp, spinelike nodes are developed horizontally across lower extremity of IBr^1, that in center followed vertically by several similar nodes, intervening spaces raised as a sharp ridge, that of the apex being stronger than the others, and protruded. This raised ray continues to the tip of the arms. The l. post. IBr^1, and ant. IBr^1, are elongated, r. ant. IBr^1, and l. ant. IBr^1 very short in comparison, r. post. IBr^1 just slightly shorter than the longest.

Tegmen is apparently composed of 4 small hexagonal plates to the row, and extends slightly beyond the arms in maturity. At the uppermost extremity there is a circlet of elongated spinelike, flattened plates, extending upward as a crown.

The proximal columnals are known, same being thin, alternating expanded, round, apparently the surface is rough as in the rest of the crinoid, and pierced by a minute, round axial canal.

In addition to the strong ornamentation previously noted, the entire surface of the calyx and arms are thickly covered by minute, spinelike nodes.

Relationship.—*Utharocrinus pentanodus*[4] (Mather) is the only other known species, same having considerably stronger developed protuberance of the BB, and lacking the strong ornamentation of the form at hand.

Occurrence and horizon.—Stanton limestone member Ochelata group, Pennsylvanian, the mound just west of the city limits of Bartlesville, Oklahoma.

Types.—Springer Collection of the U. S. National Museum.

Genus SCYTALOCRINUS Wachsmuth and Springer

Only one species has been assigned to this genus, from the Pennsylvanian strata to date, that being *S. sansabensis*[5] Moore and Plummer. It is to be noted, however, that text fig. 19 distinctly shows the l. post. primibrach as being axillary, and both of the secundibrachs of said ray being axillary, therefore the species is certain to have more than ten arms as is characteristic of the genus. Herein described are *Scytalocrinus larvalis,* n. sp., and *Scytalocrinus deminutivus,* n. sp.

Scytalocrinus larvalis, n. sp. Plate 2, figs. 11-13

It is possible that this form becomes rather large with maturity, but since it is rather common in the locales under observation, and no large specimens have appeared over the past several years, it is doubtful that the form ever becomes very robust.

Smallest observed specimen measures 4.0 mm. to tip of arms. Normal specimen measures 7.0 mm. to $IIBr^1$.

Cup turbinate-shaped; IBB5 equal pentagonal elements, rising directly from columnar scar; BB 5 large, equal, hexagonal elements, slightly higher than wide, that of the posterior being truncated for the reception of anal X, and larger than others, plates gently tumid; BB 5, small, equal, pentagonal elements, articular facets unknown beyond the fact that they are extended inward slightly as horizontal shelves and are sharply notched by a small ligamental furrow to the fore; anal series of three plates;

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[4] Mather, Denison Univ. Sci. Lab., Bull., vol. 18, 1915, p. 106, pl. 3, figs. 8, 8a, b, (as *Delocrinus*) ; Moore, R. C., and Plummer. F. B., Denison Univ. Sci. Lab., Bull., vol. 32, 1938, pp. 286-288, text fig. 31 (as *Utharocrinus*).

[5] Moore, R. C., and Plummer, F. B., Denison Univ. Sci. Lab., Bull., vol. 32, 1938, pp. 247-250, pl. 14, figs. 9a b; text fig. 9.

anal X elongo-hexagonal, resting solidly on post. B; radianal elongo-pentagonal, resting obliquely on post. B. supported by r. post. B; right tube plate small, hexagonal, resting on radianal, half in half out of cup.

Of the arms our knowledge is limited to the $IIBr^1$, above which is unknown. The IBr^1 are the most elongated of any forms yet observed, and are axillary.

The stem is known from proximal columnals only, the same being round, like elongated beads, heavily crenulated so that crenulations are visible from side view, and pierced by minute, round axial canal.

Tegmen unknown.

Ornamentation.—Aside from distinctive porosity, small nodes are visible under strong magnification, and a thin ray runs the length of IBr^1, the backs of IBr^1 being almost triangular-shaped.

Occurrence and horizon.—Pl. 2, fig. 13,—Shale-limestone lens between the Okesa sandstone and Torpedo sandstone members, Ochelata group, Pennsylvanian, 5 miles southwest of Bartlesville, Oklahoma.

Pl. 2, figs. 11, 12,—Stanton limestone member, Ochelata group, Pennsylvanian, the mound just west of the city limits of Bartlesville Oklahoma; specimens observed from—Stanton limestone member, Ochelata group, Pennsylvanian, 3½ miles due west of Ramona, Oklahoma; Stanton limestone member, Missouri series, Pennsylvanian, near Wayside, Kansas.

Types.—Springer Collection of the U. S. National Museum.

Scytalocrinus deminutivus, n. sp. Plate 2, figs. 8-10

The figured crowns are immature, the figured cup more or less mature, the smaller crown measures 6.8 mm. to tip of arms, of which the cup only accounts for 2.0 mm., by 3.0 mm. wide. Large cup measures 5.2 mm. wide, by 3.0 mm. high.

Cup turbinate-shaped; IBB 5 small, pentagonal elements, rising slightly higher than wide, that of the posterior being larger than others and truncated for reception of anal X; RR five, small, equal, pentagonal plates, articular facets developed only slightly inward as horizontal shelves, strong ligamental furrow to the fore, joined by pronounced cross ridge; shallow muscle scars developed laterally; anal series within cup three; anal X hexagonal, resting solidly on post. B., extending slightly out of cup; radianal pentagonal, resting obliquely on post. B, supported by r. post. B; right tube plate small, hexagonal, resting solidly on radianal, half in, half out of cup.

Arms are known to be ten to IIBr[3], branching on IBr[1], uniserial. Primibrachs slightly elongated, fully rounded, those of the l. post. and ant. being slightly longer than others, r. ant. and l. ant. the shortest.

Stem unknown save for proximal columnal, which is round, heavily crenulated, and pierced by minute, round axial canal.

Tegmen unknown.

Ornamentation.—Under strong magnification the plates prove smooth, the porosity in immaturity being very fine meshlike.

Relationship.—Immature specimens of this species may at first be confused with *S. larvalis,* however, the IBr[1] of the form at hand are fuller all around, not nearly so elongated, as against the thin, almost triangular-shaped backs of the IBr[1] in *S. larvalis,* and the minute nodes covering that species. *S. sansabensis* Moore and Plummer has different type of arm branching.

Occurrence and horizon.—Figured specimens, Pl. 2, figs. 8, 10 —Stanton limestone member, Ochelata group, Pennsylvanian, the mound just west of the city limits of Bartlesville, Oklahoma; Pl. 2, fig. 9—Dewey limestone, Pennsylvania, Dewey Portland Cement Quarry, Dewey, Oklahoma.

Types.—Springer Collection of the U. S. National Museum.

EXPLANATION OF PLATES

PLATE 1 (2)

EXPLANATION OF PLATE 1 (2)*

Figure | Page

1, 2, and 9. **Whiteocrinus stillativus** (White) 5

Fig. 1, view from below, fig. 2, same from above to show arm and fragment of tegmen preserved; fig. 9, well preserved specimen, from below. Stanton limestone, the mound just west of Bartlesville, Oklahoma.

3, 4. **Whiteocrinus**, sp. indet 6

Fig. 1, view from above; fig. 2, same from below, that arm to the extreme left in fig. 1, being to the extreme left, one basal, and two primibrachs shown. Stanton limestone, the mound just west of Bartlesville, Oklahoma.

5, 6. **Poteriocrinites ramonaënsis**, n. sp. 7

Fig. 1, posterior view; fig. 2, anterior view. Stanton limestone, the mound 3½ miles due west of Ramona, Oklahoma.

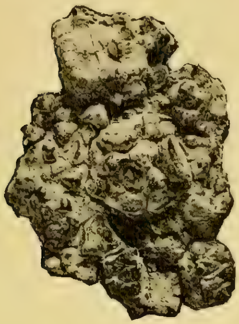
7, 8. **Whiteocrinus exculptus**, n. sp. 5

Fig. 7, view from below; fig. 8, posterior view. Stanton limestone, the mound just west of Bartlesville, Oklahoma.

10-12. **Poteriocrinites magnus** Wright 8

Fig. 10, radial plate; fig. 11, basal plate; fig. 12, infrabasal circlet. Wewoka formation, near Holdenville, Oklahoma.

* All figures natural size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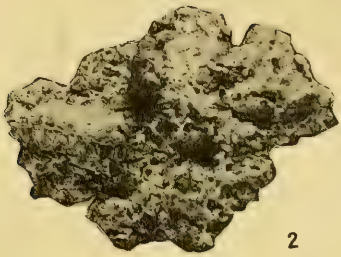
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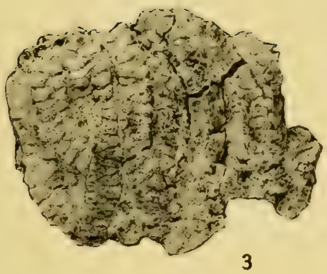
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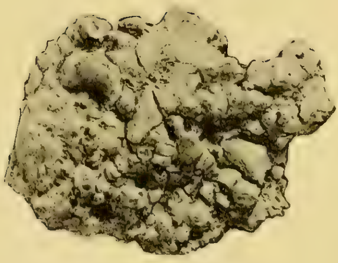
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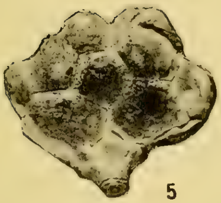
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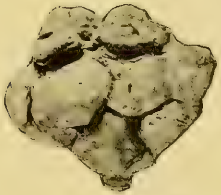
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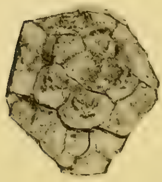
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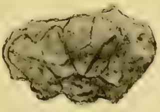
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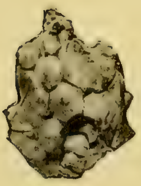
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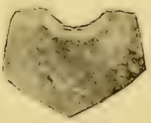
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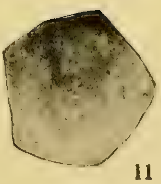
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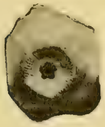
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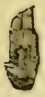
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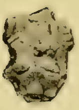
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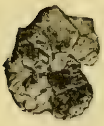
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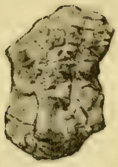
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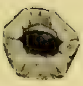
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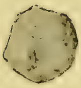
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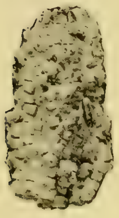
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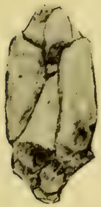
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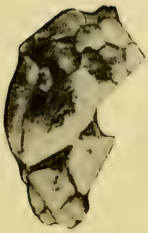
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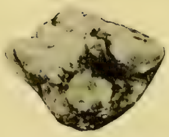
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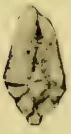
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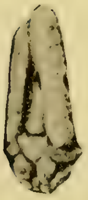
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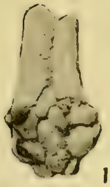
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Some Echinoids from the Cretaceous of Texas

By

William Clyde Ikins

January 3, 1940

Paleontological Research Institution

Ithaca, New York

U. S. A.

VITA

The writer, William Clyde Ikins, was born January 29, 1916, at Thurber, Texas. He entered The University of Texas in 1933 from which he received his Bachelor of Science degree in Geology with high honors in 1938. He was employed as a student assistant in the Department of Geology from September, 1936 to February, 1938 at which time he was promoted to the rank of tutor. Since then he has served as such. He served as an assistant geologist in the Bureau of Economic Geology in the summer of 1938. He became a member of Sigma Gamma Epsilon in November, 1936. He acted as secretary-treasurer of the Southwestern Geological Society in the school year 1938-1939. He was elected an associate member of the Society of the Sigma Xi in May, 1939. The permanent address is 2608 McCallum Drive, Austin, Texas.

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JAN 10 1940

SOME ECHINOIDS FROM THE CRETACEOUS OF TEXAS*

By

William Clyde Ikins

ACKNOWLEDGMENTS

The writer wishes to express his most sincere appreciation to all those who have made the preparation of this paper possible. He is indebted to Dr. F. L. Whitney who has given his advice, time, the use of his library, and his aid in photographing specimens.

To Dr. F. M. Bullard, he is indebted for giving his time in reading the manuscript.

To Dr. G. C. Engerrand he wishes to express appreciation for encouragement and time in reading the manuscript.

INTRODUCTION

At the suggestion of Professor F. L. Whitney, work was begun on the study of a collection of Cretaceous echinoids which he had assembled. The collection was not made from any particular locality or stratigraphic level but was obtained from various parts of the State and from several Cretaceous formations. This work is not an attempt to study the echinoids stratigraphically, but an attempt to describe the new species which were contained in the collection as well as to correct certain errors in classification which have been made and incorporated in the literature.

The stratigraphic significance of echinoids in the Texas Cretaceous would be of interest as there has been very little work done on this subject. The author hopes to be able to continue his studies of the echinoids along this line.

---

* Presented to the Faculty of the Graduate School at the University of Texas in partial fulfillment of the requirements of the degree of Master of Arts.

Austin, Texas.
June, 1939.

William Clyde Ikins, B.S.

SYSTEMATIC DESCRIPTIONS

Genus **LORIOLIA** Neumayr, 1881*

Loriolia texana (Roemer).—This species, which was described by Roemer as a *Diadema* has been recently assigned by some workers to the genus *Loriolia* while others refer it to the genus *Pseudodiadema.* If the specimens of this species from the Glen Rose formation contained the apical system, this problem would be easily solved. Under these circumstances other generic characters must be considered. These two genera are similar in that they both have tubercles of equal size in the ambulacra and interambulacra. They are also perforate and crenulate. The pores of both are uniserial and the ambulacral plates simple.

According to Desor's figures of the types of the genus *Pseudodiadema,* the apical system is quite circular and not elongated on the posterior-anterior axis. Likewise the ambulacra converge to a central point and there is no noticeable separation of bivium and trivium.

The figures of the type of the genus *Loriolia* show, as pointed out by Neumayr, that there is a noticeable separation of bivium and trivium. Hence the apical system is elongated along the posterior-anterior axis. This genus is characterized by a groove in the posterior portion of the discal opening. It is not known, as pointed out by Neumayr, whether there was a posterior genital plate in this groove or whether the anus pierced the apical apparatus at this point and the posterior genital plate was absent.

Of the specimens studied, none contained the apical disk, but the discal opening is elongated along the posterior-anterior axis and there appears to be a noticeable separation of bivium and trivium. The groove in the posterior portion of the opening is strongly developed. These characters point to the genus *Loriolia.*

A literal translation of the original descriptions of these two genera now follows:—

Genus **LORIOLIA** Neumayr, 1881

In all characteristics with the exception of apex *Loriolia* accords with *Pseudodiadema;* the summit is indeed only incompletely known, deviates essentially from all hitherto observed regular sea urchins; in the first line is itself strongly elongated so that the ambulacra do not converge in a point but a distinct separation of bivium and trivium takes place. The apical apparatus has the form of an elongated ellipse; whether the anus by itself was enclosed in a circle and bordered behind by a strong bordered genital plate, or whether it pierces the apical apparatus at this point and the posterior genital plate absent, is questionable. Even so it is unknown whether the anal opening occupied the whole elongate elliptical space surrounded by genital and ocular plates or whether supernumerary plates appeared whereby *Loriolia* would be related to *Salenia.*

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* Neumayr, M., *Ueber Loriolia, eine neue Echinidengattung,* Deutsche Geol. Gesell. Zeitschr. 33, 1881, pp. 570-573.—*Eds.*

Our information in this direction is of course still very incomplete, only so much is certain, that here is exhibited a deviation from all Pseudodiademas and all regular sea urchins that a separation appears necessary. We find the nearest point of comparison first in the *Echinonei* under which many *Hyboclypeus* species with highly situated anus show extraordinary conformity. If one, for instance, considered the summit from *Hyboclypeus gibberulus* one must concede that here only a slight difference prevails.

A genus which *Loriolia* probably stands very near is the remarkable *Heterodiadema;* also, we find here, in all the characters with exception of anus and apical apparatus, near conformity with *Pseudodiadema,* also, we see deep notching of the posterior interambulacral zone; unfortunately nothing is known about the development of the apical appartus in *Heterodiadema,* it has fallen out of all specimens and one observes only the gap which the anus and summit together produce in the corona. In all probability *Heterodiadema* is, as has already been brought forth several times, nearest related to young forms of *Acrosalenia,* in which the anus strongly hollows out the posterior genital plate (*Milnia* Haime). Presumably *Loriolia* also will rank here through an association with *Heterodiadema* is in no case permissible, the strong separation of bivium and trivium furnishes a very fundamental diagnostic character for *Loriolia.*

The specimen which constitutes the type of *Loriolia* has been figured by Cotteau under the name *Pseudodiadema Bourgueti;* there arises next the question whether all the pieces of this species occurring in the Neocomian in considerable numbers belong to the new genus.

Genus **PSEUDODIADEMA** Desor, 1858

Urchins of medium and small size. Tubercles are not inequal as in the preceding genera but of equal size on the two areas, besides crenulate and perforate, sometimes forming only two rows in the secondary series, sometimes disposed in four and even six rows in the interambulacral areas. Poriferous zones simple. Radioles in the form of smooth spines well striated longitudinally when one examines them with a magnifying glass. They are encountered from the lower Oolite up to the base of the Tertiary.

Genus **TROCHOTIARA** Lambert, 1901

Trochotiara texana (Roemer).—This interesting species from the Walnut formation has been assigned by some workers to the genus *Polydiadema* while others assign it to the genus *Trochotiara.* These two genera are quite similar but they differ in the structure of the ambulacral plates. *Trochotiara* has ambulacral plates which are *trisocieés.* By this we mean that the large plate which contains the primary tubercle is made up of three parts each of which contains one pair of pores. Near the ambitus there may be a supplementary plate.

Polydiadema has ambulacral plates which are *quadrisociées* from the apex to below the ambitus.

This species from the Walnut formation has ambulacral plates which are *trisociées;* therefore, it belongs to the genus *Trochotiara.* A literal translation of the descriptions of these two genera now follows:—

Genus **TROCHOTIARA** Lambert, 1901

Test of small size, depressed, circular, peristome quite large and apex broad and frail, pentagonal. The ambulacral *majeures trisociées* with sometimes a supplementary plate at the ambitus. Poriferous zones unigeminal divided near peristome. Ambulacral tubercles not contrasting the interambulacral in principal series flanked or not with secondaries. Milliary zone broad, naked, depressed at its upper surface and ornamented with more or less abundant equal granules. The radioles are elongate, cylindrical, and of smooth appearance.

Genus **POLYDIADEMA** Lambert, 1888

Test subpatelliform more or less depressed with large, deepened and notched peristome. Apex large and fragile. Poriferous zones are undulating, unigeminal and divided toward the peristome. Majeures quadrisociées from the apex to below the ambitus. Tubercles well developed and a little larger at the ambitus, the interambulacra covering the major part of the plates with scrobicular circles more or less incomplete and some inequal, separated granules.

Genus **DIPLOPODIA** McCoy, 1848

Subgenus **TETRAGRAMMA** Agassiz, 1840

Several species of echinoids from our Cretaceous deposits have been recently assigned by some workers to the genus *Tetragramma* while others assign them to the genus *Diplopodia.* An examination of the figures of the types of these two genera shows that they are both characterized by pores which are uniserial but doubled near the discal opening. The tubercles are crenulate and perforate and the ambulacral plates are compound in both. The only difference between the two is that *Tetragramma* has secondary rows of tubercles which are equal in size to the tubercles in the primary rows. By secondary rows of tubercles we mean those which do not extend all of the way from the apex to the peristome. Hence these are present only near the ambitus and they do not extend to the poles. By primary rows of tubercles we mean those which extend from the apex to the peristome.

In the true *Diplopodia* the secondary rows of tubercles when present are not equal in size to those of the primary rows.

This distinction seems to be based on a character which might be debatable. Some would consider this a specific character while others would consider it important enough to establish a genus. On this basis it seems best not to class *Tetragramma* as an independent genus but to place it as a subgenus of *Diplopodia.*

The following Texas species belong to the subgenus *Tetragramma*:—

Tetragramma taffi (Cragin), 1893—Comanche Peak.

Tetragramma streeruwitzi (Cragin), 1893—Washita.

Tetragramma texanum (Roemer) Clark, 1893—Fredericksburg.

The following Texas species belongs to the genus *Diplopodia*:—

Diplopodia hilli (Clark), 1893—Austin chalk.

A literal translation of the original description of the subgenus *Tetragramma* now follows:—

Genus **TETRAGRAMMA** Agassiz, 1840

The species which I arranged in this new genus are very close in many respects to the type of *Diadema.* They are, like them, urchins of medium and small size having the tubercles perforate and the pores disposed in simple pairs. The buccal opening is of medium size. It is probable also that the oviductal apparatus and dental apparatus do not sensibly differ, but along with these analogies, one notices a particular character which, on account of its constancy, appeared to me to necessitate a new division in the group of Diademas. This distinctive character of the new genus comes from the distribution of the tubercles: in place of two rows of primary tubercles on each area, we have at least four on the interambulacral areas and two on the ambulacral areas. It results as a direct consequence that the Tetragrammas or urchins with four primary rows on the interambulacral area should have a more worty and rougher aspect than the true Diademas. The several rows of tubercles are almost equal. In the true Diademas on the contrary one constantly notes a more decided difference in the primary rows and the secondary rows, some developed so that they might be the latter.

These differences may appear, perhaps too insignificant to justify a generic separation; nevertheless, one is forced to accord a real value, when one considers the numbers of species of true Diademas and their great uniformity.

The tubercles carry, in all of the known species, perforated and slightly crenulated mamelons. The spines are unknown. I have taken for type of my new genus *T. variolare* (*Cidarites variolaris* Al. Brongniart) so frequent in the marly chalk.

Genus **PHYMOSOMA** Haime, 1853

Cyphosoma Agassiz, 1838 (not Mannerheim, 1837)

The genus *Phymosoma* should have priority over the genus *Cyphosoma* (Agassiz, 1838) for when Agassiz described the genus in 1838 he was not aware that Mannerheim had established the name of a genus of the Coleoptera in 1837.

The following Texas species belong to the genus *Phymosoma*:—

Phymosoma texanum (Roemer), 1852—Trinity and Fredericksburg.

Phymosoma mexicanum Böse, 1910—Fort Worth to Denton.

Phymosoma volanum (Cragin), 1892—Washita.

Genus **ENALLASTER** d'Orbigny, 1853

Plate 4, figs. 1a, 1b

This genus has been listed by some workers as being synonymous with *Heteraster* d'Orbigny (Plate 4, figs. 2a, 2b). This classification, however, could not have been based on careful observation, for they are two distinct genera as pointed out by D'Orbigny in 1853. These two genera are quite similar in general appearance, but upon careful study of the unpaired ambulacrum, one sees that the plates of *Enallaster* are simple while those of *Heteraster* are compound. *Heteraster* has three kinds of pores; simple internal pores which are small and aligned in a single vertical row, elongated transverse external pores, and between these accessory pores which are in special plates and which alternate at irregular intervals with the other two types of pores. *Enallaster* has two types of pores which are placed in simple plates; very elongate, transverse pores, and small, simple pores. The inner pores of the transverse pores are not vertically aligned with the inner pores of the small pores; therefore there is a staggering of the inner pores of the two types. According to D'Orbigny's description of the genus as well as to his figures, these two types of pores alternate at regular intervals. It has since been proven, however, that the alternation is not regular. *E. traski* Whitney, for example, from the Buda limestone has two pairs of elongate pores followed by a pair of round pores; then five pairs of elongate pores followed by a pair of round ones, which are then followed by three pairs of elongate pores, before another pair of round pores occurs.

The peristome of *Enallaster* is transverse while that of *Heteraster* is pentagonal.

A literal translation of the original descriptions of these two genera now follows:—

Genus **ENALLASTER** d'Orbigny, 1853

Hemipneustes Forbes, 1852 (not Agassiz, 1836)
Toxaster Roemer, 1850 (not Agassiz)

Characters. Genital and ocular apparatus as of the two preceding genera with this difference, at least according to the figures of Mr. Forbes in which he has in front of the four genital plates a complimentary plate. *Mouth* transverse, not labiate; *anus* oval, supramarginal *Ambulacra* subpetaloid, inequal. *Unpaired ambulacrum* very broad, placed in a groove, entirely unlike others: the two branches are composed of pores very unlike those of the others; one sees in a regular alternative succession a pair of very elongate pores, transverse, and a pair of simple pores, very small, and that on all the broad part of the ambulacrum: the rest is provided with equal pores. *The ambulacral pairs* are superficial, very inequal in length, formed of inequal zones, the broader behind. No fascioles. Tubercles inequal, rare, crenulate, and scrobiculate. Shell thin, cordiform, depressed.

Relations and differences. With all of the principal characters of *Echinospatagus* and *Heteraster*, this genus is distinguished only by its unpaired ambulacrum. This instead of being formed of equal successive pores as with the first, or of three sorts of pores on three parallel lines, like the second, has pores of very different form alternating with one another on each of the two poriferous zones. It is one of the most singular conformation of pores which we know among the echinoids.

Genus **HETERASTER** d'Orbigny, 1853

Spatangus (in part) Brongniart

Toxaster (in part) Agassiz, 1840

Characters. Genital and ocular apparatus as among the other genera of the family and especially as among the *Echinospatagus*. *Mouth* pentagonal, not labiate. *Anus oval,* supramarginal. *Subpetaloid ambulacra* inequal. *The unpaired ambulacrum* placed in a slight groove composed of three kinds of pores; of simple internal pores, small; of elongated, transverse external pores, and between these accessory pores interculated and alternating with the others at irregular distances and depending on special interculated plates which unite these internal pores and the external ones. *The ambulacral pairs* are almost superficial or slightly excavated, very inequal, the anterior one the longer, all subpetaloid. They are formed of inequal pore zones the posterior one large; the other anterior narrow. In each zone the anterior range is formed of simple pores. The external range of much larger pores generally transverse. Outside of the petaloid parts of the ambulacra there are only small simple pores. There is no fasciole. Tubercles rare, separated, inequal, crenulate, and often scrobiculate. Shell thin, cordiform, oval, and depressed.

Relations and differences. With all of the principal external characters of *Echinospatagus,* those which distinguish it are three sorts of pores in place of two in the unpaired ambulacrum, that is to say of internal and external pores in each zone, and of intermediate pores interculated between them and assigned to special plates placed between the ordinary plates.

The only two species known are from the upper Urgonian region of the 17th Neocomian stage. Both were described by Mr. Agassiz as *Toxaster*. It is quite singular that this author with all that he had to say about the two species did not notice the pores so different in the unpaired ambulacrum.

Therefore, the following Texas species belong to the genus *Enallaster*:—

Enallaster texanus (Roemer), 1852—Fredericksburg and Washita.

Enallaster obliquatus Clark, 1915—Glen Rose.

Enallaster texasus d'Orbigny, 1853—Fredericksburg.

Enallaster bravoensis Böse, 1910—Washita.

Enallaster wenoensis Adkins, 1920—Weno and Pawpaw.

Enallaster traski Whitney, 1916—Upper Buda.

Enallaster adkinsi Lambert, 1927—Duck Creek.

Enallaster inflatus Cragin, 1892—Grayson.

DESCRIPTION OF SPECIES

Order **CENTRECHINOIDA** Jackson

Suborder **ALODONTA** Jackson

Family **CENTRECHINIDAE** Jackson

Genus **CODIOPSIS** Agassiz, 1840

Codiopsis sellardsi, n. sp. Plate 1, figs. 1a, 1b, 1c

Description.—The test is medium in size, elevated and globose. When viewed from above, it is subpentagonal in outline, the ambulacral areas being at the angles and the interambulacral areas forming the sides. The superior surface is elevated and abruptly rounded whereas the inferior surface rounds gently from the ambitus to the peristome.

The ambulacral areas are narrow being only about one-third of the width of the interambulacral areas. They are straight and increase in width from a point at the apical disk to a maximum width of about 5 mm. at the ambitus. Only fine granules are scattered above the ambitus. Reaching over about two-thirds of the distance from the peristome to the ambitus, there are two alternating rows, of about six each, of round, noncrenulate, imperforate, mamillated tubercles. Two rows of alternating granules are situated adradially from the tubercles. The pores above the ambitus are round and are located in a slight depression. They are arranged in groups of three to each ambulacral plate. The pore pairs increase below the ambitus until there are four rows of pores at the peristome. Between each pair of pores in this region there is a granule.

The interambulacral areas are wide and depressed. The surface above the ambitus is ornamented with minute granules arranged in such a manner as to form fine longitudinal lines. Below the ambitus, there are four rows of noncrenulate, imperforate, mamillated tubercles which diverge from the peristome, two rows being in either half of the area. In the adradial rows there are from seven to eight tubercles, while in the median rows there are from three to four tubercles.

The peristome is small, without notches, and is elongate and oval along the lateral axis. The specimen has been slightly crushed, but the peristome was undoubtedly oval before the crushing occurred.

The apical system is small and is composed of five genital and five ocular plates. The right anterior genital is larger than the others and contains the madreporite which is irregular in shape and occupies most of the plate. The genital plates are perforated by large round pores which are located on the outer margins of the plates. The ocular plates are irregular in shape and are almost bell-shaped. Perforations on the outer ends of the plates are not to be observed. The periproct is almost circular in shape.

Related forms.—This species closely resembles *Codiopsis texana* Whitney in proportions and in general appearance, but it may be distinguished by its elongate, oval peristome and its more globular form. The tubercles of this species do not seem to be so well developed.

Dimensions.—Diameter at ambitus, 33 mm.; height, 28 mm.; apical disk, 11 mm.; peristome, about 10 mm. along the posterior-anterior axis and about 15 mm. along the lateral axis.

Occurrence.—Stratigraphic level not known—probably upper Fredericksburg—found with other Fredericksburg fossils.

Locality.—Seven Mile Mesa near Fort Stockton, Texas.

Genus **PEDINOPSIS** Cotteau, 1863

Pedinopsis engerrandi, n. sp. Plate 1, figs. 2a, 2b, 2c

Description.—Test medium size, circular in outline, subconical, sides inflated; adactinal surface flat; abactinal surface concave.

Ambulacra straight and quite narrow being 1 mm. at the apical disk, 4 mm. at the ambitus, and 1.5 mm. at the peristome. Surface ornamented with six rows of primary tubercles at the ambitus, the two marginal ones being complete, the four inner ones incomplete. The tubercles are perforate and finely crenulate. Pores biserial, small, and round; ambulacral plates compound.

The interambulacral areas are wider than the ambulacral areas and they widen from 1.5 mm. in the plocogenous zone to 8.2 mm. in the median zone, and 2.5 mm. at the peristome. Surface ornamented with twelve rows of perforate, finely crenulate tubercles at the ambitus, which become reduced toward the peristome. Tubercles equal in size with those of the ambulacra. Small granules are scattered over the ambulacra and interambulacra.

The actinal surface is in a poor state of preservation, but the peristome is about 8 mm. in diameter and is marked by ten distinct incisions in the interambulacra.

The apical system is not preserved, but it was apparently about 4 mm. in diameter.

Related forms.—This species is quite similar to *Pedinopsis yarboroughi,* n. sp., but the abactinal surface of this species is concave rather than convex.

It has a slight resemblance to *Pedinopsis desori* Cotteau from the Cenomanian of Europe, but the abactinal surface of this species is concave while that of *P. desori* is convex and elevated.

Dimensions.—Diameter at ambitus, 21 mm.; height, 11.5 mm.; apical disk, 4 mm.; peristome, 8 mm.

Occurrence.—Lower clays of Walnut formation.

Locality.—Outcrop on Anderson Mill road just west of Marshall Ford Dam road, Travis County, Texas.

Pedinopsis yarboroughi, n. sp. Plate 1, figs. 3a, 3b, 3c

Description.—The test is circular in ambital outline, globose, sides inflated; abactinal surface gently convex; adactinal surface almost flat with a slight concavity near the peristome.

The ambulacral areas are narrow and straight. They widen gently from 1 mm. at the apical disk to 5 mm. at the ambitus, then narrow down to 3 mm. at the peristome. The surface is ornamented with six rows of tubercles at the ambitus. The outer rows are complete and reach from the apical disk to the peristome while the inner rows do not extend to the poles. The tubercles are finely crenulate and perforate. Granules are quite numerous between the tubercles. The plates are compound. The pores are small and biserial.

The interambulacral areas are broader than the ambulacral areas and are composed of two rows of alternating plates. There are fourteen rows of tubercles at the ambitus, which become reduced to four at the peristome. The tubercles are finely crenulate, perforate, and are about the same size as those of the ambulacral areas. Small granules are scattered over the plates.

The apical disk is not present, but it must have been about 4.5 mm. in diameter.

The peristome is round and is marked by ten distinct incisions in the interambulacra.

Related forms.—This species slightly resembles *Pedinopsis pondi* Clark in general appearance, but the sides are more inflated. There are only fourteen tubercles in the interambulacral area at the ambitus instead of eighteen.

It differs from *Pedinopsis engerrandi,* n. sp. in that it is more elevated and globose and that the abactinal surface is gently convex instead of concave.

Dimensions.—Diameter at ambitus, 24 mm.; height, 15 mm.; apical disk, 4.5 mm.; peristome, 9 mm.

Occurrence.—Lower clays of Walnut formation.

Locality.—Outcrop of lower Walnut on the north side of the road at Dies ranch on the Pond Springs School-Anderson Mill road, Travis County, Texas.

Suborder STIRODONTA Jackson

Family SALENIIDAE Desor

Genus SALENIA Gray, 1835

Salenia leanderensis, n. sp. Plate 1, figs. 4a, 4b, 4c

Description.—The test is circular in ambital outline, sides slightly inflated; abactinal surface gently and regularly rounded; adactinal surface practically flat.

The ambulacra are quite straight and wide. They are about one-half the width of the interambulacra at the ambitus and they widen only slightly between the apical disk and the peristome. The surface is ornamented with two alternating rows of about twelve imperforate, crenulate, mamillated tubercles. There are no granules between the tubercles. The pores are round, unigeminal, and become irregular as well as crowded upon approaching the peristome.

The interambulacra are composed of two rows of alternating plates, five to a row. Each plate is ornamented with a scrobiculate boss which bears an imperforate, crenulate mamelon. Granules are arranged such that there is a granule in the upper and lower adradial corners as well as five on the medial margin of each plate.

The peristome is decagonal and is quite large, being over one-half the diameter of the shell. The ambulacral and interambulacral lips are practically equal. The branchial incisions are well developed.

The apical disk is circular in outline and is raised above the surface of the shell. It is composed of five ocular and five genital plates as well as the suranal plate. There appears to be no ornamentation on the plates. The oculars are triangular in shape. The genitals are each perforated by a pore which is located near the center of the plate. The incision in the right anterior genital plate extends from the genital pore to the margin of the plate so that it is difficult to locate the first pore between the ocular and genital plates. The periproct is slightly deltoid but rounded at the angles.

Related forms.—This species has no doubt been misidentified as *Salenia mexicana* Schlüter, but it may be readily distinguished by its size, the number of ambulacral tubercles, about twelve instead of eighteen to twenty, and the shape of the shell. This species has only five interambulacral plates while *S. mexicana* usually has six.

This species bears a resemblance to *Salenia phillipsæ* Whitney from the Glen Rose formation in general appearance, but it has about twelve ambulacral tubercles instead of five. It has five interambulacral plates in each row instead of four. The apical system is circular and not pentagonal.

Dimensions.—Diameter at ambitus, 9 mm.; height, 5 mm.; apical disk, 6 mm.; peristome, 5 mm.

Occurrence.—Upper clays of Walnut formation.

Locality.—Borrow pit on west side of road, 1 mile north of Leander, Texas.

Salenia pseudowhitneyi, n. sp. Plate 1, figs. 5a, 5b, 5c

Description.—The test is medium in size, circular in ambital outline; abactinal surface depressed convex; adactinal surface slightly concave, sides inflated and regularly curved.

The ambulacral areas are narrow and slightly flexuous. The surface is ornamented with two rows of about nineteen alternating circular, imperforate, mamillated tubercles. Between each pair of tubercles there is a pair of granules. The pores are uniserial, round, and are slightly crowded but quite regular upon reaching the peristome.

The interambulacral areas are wide and consist of two rows of seven broad, alternating plates. Each plate contains a large, scrobiculate, crenulate boss which bears an imperforate mamelon. Granules are so arranged in the middle of the area that there are two rows of large granules with two rows of smaller granules between them. There is also a large granule in the upper and lower adradial corners of each plate.

The peristome is large, circular, decagonal, and contains strongly developed branchial incisions.

The apical system is large, subpentagonal, and is composed of five ocular and five genital plates as well as the suranal plate. The ocular plates are small, subtrigonal, and their basal margins are extended with respect to the basal margins of the genitals. The genitals are broad and their basal margins are not pointed but gently rounded. Their shape along with the shape of the oculars gives the outer margin of the apical disk a scalloped appearance and disrupts a true pentagon. The incision in the right anterior genital plate is crescent-shaped and extends from the genital pore to the margin of the plate.

Related forms.—This species is very similar to *Salenia whitneyi* Cannon in many respects, but it may be distinguished by the shape of the apical system which is not pentagonal but subpentagonal and scalloped on the outer margin. The genitals of this species are not depressed with respect to the oculars so that when viewed laterally the base of the apical disk is a straight line instead of a zigzag line. The genital plates are broader and are not pointed at the base but gently rounded.

Dimensions.—Diameter at ambitus, 17.1 mm.; height, 10.5 mm.; apical disk, 11 mm.; peristome, 7.5 mm.

Occurrence.—Anacacho formation.

Locality.—Lower chalky marl at King's Water Hole on Hondo River, 2 miles north of Hondo, Texas.

Salenia scotti, n. sp. Plate 2, figs. 1a, 1b, 1c

Description.—The test is subcircular in outline at the ambitus; abactinal surface greatly elevated, the sides slightly inflated; adactinal surface flat.

The ambulacral areas are straight and narrow, slightly widening from 1.5 mm. at the apical disk to 2 mm. at the peristome. The surface is ornamented with two rows of about nineteen alternating tubercles which are imperforate, mamillated, and circular in outline. Situated between these are small granules which become quite noticeable opposite the second ambulacral tubercle above the peristome. The pores are round, some being elongated horizontally, uniserial, and become more numerous as well as irregular upon approaching the peristome.

The interambulacral areas are wider than the ambulacral being 4 mm. wide in the plocogenous zone, 6.5 mm. in the median zone, and 4 mm. at the peristome. They consist of two rows of large alternating plates, six being present in each row. The primary tubercles decrease in size from the abactinal surface to the peristome where they are about the same size as the tubercles within the ambulacral areas. Each plate contains a large, scrobiculate, crenulated boss which bears an imperforate mamelon. The granules are so arranged on the margins of plates that there are two in the upper adradial corner and only one on the lower adradial corner, while on the medial margins of the plates there are four. Milliaries occur between the granules on the medial margins of the plates.

The peristome is large, about one-half the diameter of the test, and is circular in shape. The basicoronal plates bear ten greatly developed incisions which divide the peristome into ten almost equal parts.

The apical system is large, circular, and is composed of five ocular and five genital plates and the suranal plate which is located in the center of the system by the periproct. There are radiating furrows which extend out from the suranal plate toward interambulacra 1, 2, and 3. Between these furrows are two delta-shaped depressions which with the furrows give the apical disk, a characteristic ornamentation. The incision in the right anterior genital plate is irregular in shape. The periproct is elevated and triangular or deltoid in shape.

Related forms.—This species is somewhat similar to *Salenia mexicana* Schlüter in that it has about nineteen ambulacral tubercles, but it is much more elevated. The periproct of this species is much more prominent and the ornamentation of the apical disk is entirely different. This species differs from *S. volana* Whitney in that it has about nineteen ambulacral tubercles whereas *S. volana* has about fifteen to seventeen. This species is also much more elevated.

Dimensions.—Diameter at ambitus, 16 mm.; height, 12 mm.; apical disk, 9.5 mm.; peristome, 8 mm.

Occurrence.—Upper *Salenia* level of the Goodland formation.

Locality.—Unknown.

Salenia stenzeli, n. sp. Plate 2, figs. 2a, 2b, 2c

Description.—The test is circular in outline at the ambitus; abactinal surface only slightly convex; sides inflated; adactinal surface almost flat and only slightly concave.

The ambulacral areas are flexuous and quite narrow, slightly widening from 1 mm. at the apical disk to about 2 mm. at the peristome. The surface is ornamented with two rows of about sixteen alternating tubercles which are imperforate, mamillated, and circular in outline. Small granules are situated between these tubercles. The pores are round, uniserial, and become irregular as well as more numerous upon reaching the peristome.

The interambulacral areas are wider than the ambulacral areas being 4 mm. wide in the plocogenous zone, 6.5 mm. in the median zone, and 3 mm. at the peristome. They consist of two rows of six alternating plates each of which is ornamented with a scrobiculate, crenulated boss upon which rests an imperforate mamelon.

The peristome is small, about one-third of the diameter of the test, and is circular in outline. The incisions in the basicoronal plates seem to be only slightly developed.

The apical system is large, about two-thirds of the diameter of the test, and is circular in outline. It is composed of five ocular and five genital plates as well as the suranal plate which is located in the center of the system. The incision in the right anterior genital plate is crescent-shaped. The periproct is circular in shape and is only slightly elevated.

Related forms.—This species slightly resembles *Salenia neocomiensis* Cotteau from the Neocomian of Europe, but it has six interambulacral plates and about sixteen ambulacral tubercles, whereas *S. neocomiensis* has only five interambulacral plates and about eighteen ambulacral tubercles.

It may be distinguished from *Salenia mexicana* Schlüter by its general outline. The shell is inflated and the sides round off to an almost flat abactinal surface.

Dimensions.—Diameter at ambitus, 14 mm.; height, 9 mm.; apical disk, 9.5 mm.; peristome, 5.7 mm.

Occurrence.—In the *Exogyra whitneyi* shale of the Grayson formation.

Locality.—C. Muleros, opposite the smelter, El Paso, Texas.

Salenia whitneyi Cannon, n. sp. Plate 2, figs. 3a, 3b, 3c

Description.—Test medium in size, elevated, the aboral surface depressed, convex, the adoral surface nearly flat, slightly concave, the sides inflated and regularly curved.

The apical system is pentagonal, depressed, conical. The ocular plates are small, subtrigonal, their basal margins continuous with the basal margins of the genitals forming the sides of the pentagonal outline. The genital plates are elongate, their basal extremities being the apices of the pentagon. Two small ridges ornament the margins of the genitals; the oculars are without ornamentation. The madreporite is narrow, elongate, extending from the genital pore to the margin of the plate.

The periproct is subtrigonal, bordered about equally by the suranal, the posterior genital, and the right posterior genital plates.

The ambulacra are narrow and flexuous. The nonporiferous areas are provided with two rows of rounded, mamillated, alternating tubercles, 22-24 in each row, between each pair of which is a pair of prominent granules. The pores are circular, arranged in unigeminal series, those nearest the ambitus being the largest.

The interambulacra are broad and supplied with two rows of mamillated primary tubercles, 6-7 in a row, two rows of large granules in zigzag alignment, two rows of smaller granules between the larger, and many minute granules encircling the others.

The peristome is large, depressed, decagonal, the branchial notches strong.

Young forms lack the regularity of arrangement of granules in the interambulacra, are often relatively more depressed, and have the pentagonal outline of the apical system destroyed by protruding ocular plates.

Dimensions.—Height, 16 mm.; diameter, 23 mm.; diameter of apical system, 15 mm.

Remarks.—This species is somewhat similar to *Salenia bellula* Clark, but is larger, has no ornamentation on the apical disk, has a subtrigonal periproct, and has more primary tubercles on both the ambulacra and interambulacra.

Occurrence.—Basal chalky marl at King's Water Hole on Hondo River about 2 miles north of Hondo, Texas.

Genus **GONIOPHORUS** Agassiz, 1838

Goniophorus whitneyi, n. sp. Plate 2, figs. 4a, 4b, 4c

Description.—The test is circular in outline, sides slightly inflated; abactinal surface slightly rounded but pointed at the apex; adactinal surface gently concave.

The ambulacral areas are slightly flexuous and lanceolate, changing only slightly in width between the apical disk and peristome. The surface is ornamented with two rows of about fifteen alternating, imperforate tubercles. Between the tubercles are two rows of alternating granules. The poriferous zones are composed of about twenty-nine circular, alternating, uniserial pores which become slightly irregular upon reaching the peristome.

The interambulacral areas are broader than the ambulacral areas being 2.5 mm. wide in the plocogenous zone, 4 mm. at the ambitus, and 1 mm. at the peristome. They consist of two alternating rows of seven plates each. Each plate contains a crenulated, scrobiculate boss which bears a spherical imperforate mamelon. The plates are largest at the ambitus and they diminish in size toward the poles. Granules are arranged on the margins of the plates such that there is a granule in the upper and lower adradial corners as well as in the upper and lower medial corners. Small bands of milliaries are located all along the margins of the plates.

The peristome is small, only about one-third of the diameter of the test and is circular in shape. The incisions in the basicoronal plates are but slightly developed.

The apical system is quite large, pentagonal, and composed of five ocular and five genital plates as well as the suranal plate which is located in the center of the system. The posterior genital is so arranged that it is not in contact with either of the lateral genitals due to the position of the periproct, hence oculars I and V are insert whereas II, III, and IV are excert. There are two radiating ridges which radiate from the apex of the suranal plate toward the center of the right and left anterior genital plates. On each genital plate there are two elevated granules, one being on either side of the pore. The incision in the right anterior genital plate is deltoid in shape. The periproct is large and circular being slightly elongated laterally.

Related forms.—In general appearance this species slightly resembles *Goniophorus scotti* Lambert, but it is over twice as large in size. The apical disk is markedly different in ornamentation. This species has seven plates in the interambulacral areas whereas *G. scotti* has only six. Likewise this species has about fifteen ambulacral tubercles while *G. scotti* has only about ten.

This species differs from *Goniophorus lunulatus* Agassiz, the genotype, from the Cenomanian of Le Havre, in having seven interambulacral plates as compared to six. The periproct of this species is more nearly round and the ornamentation of the apical disk is entirely different. The subtubercular pores of this species are less prominent.

Dimensions.—Diameter at ambitus, 9.5 mm.; height, 6.5 mm.; apical disk, 5 mm.; peristome, 3 mm.

Occurrence.—Del Rio formation. About ten feet below the Buda-Del Rio contact.

Locality.—Fifteen hundredths mile east of the road at a point .4 mi. south of the Marathon-Alpine-Terlingua road fork. Buck Hill quadrangle, Brewster County, Texas.

Family **PHYMOSOMATIDAE** Meissner

Genus **PHYMOSOMA** Haime, 1853

Phymosoma bybeei, n. sp. Plate 2, figs. 5a, 5b, 5c

Description.—Test subpentagonal, sides inflated and regularly curved; adactinal and abactinal surfaces almost flat.

The ambulacra are straight and broad. They widen gently from 2 mm. at the apical disk to 9 mm. at the ambitus then narrow down to 5 mm. at the peristome. The area is composed of two rows of alternating, compound plates, twelve or thirteen to a row. Each plate is ornamented with a scrobiculate, crenulate boss which bears a spherical, imperforate mamelon. Granules are scattered over the medial and adradial margins of the plates. The poriferous zones are broad and straight. Above the ambitus the pores are biserial, while below the ambitus they are uniserial, but upon approaching the peristome they become irregular and crowded.

The interambulacra are narrow and are composed of two rows of alternating plates, twelve to a row. Each plate is ornamented with a large scrobiculate, crenulate boss which bears an imperforate mamelon. These are located near the medial margin of the plate. Near the adradial margin of each plate there is a mamelonated granule. Hence there are only two rows of primary tubercles in the area. Granules are scattered on the medial and adradial margins of the plates.

The peristome is large, depressed, and marked by ten strongly developed branchial incisions. The ambulacral lips are broader than those of the interambulacra.

The discal opening is large and pentagonal. The angles occur at the medial suture of the interambulacral areas.

Related forms.—This species has no doubt been misidentified as *Diplopodia hilli* (Clark) which also occurs in the Austin chalk. Clark assigned his species to the genus *Cyphosoma* but according to his figures as well as to his description, the tubercles of his species are perforate. Hence it does not belong to this genus. This species is characterized by imperforate tubercles which are crenulate as well as scrobiculate.

Dimensions.—Diameter at ambitus, 31 mm.; height, 13 mm.; apical opening, 11.5 mm.; peristome, 13.5 mm.

Occurrence.—Austin chalk.

Locality.—One and one-half mile west of Dessau, Travis County, Texas.

Genus **PSEUDODIADEMA** Desor, 1858

Pseudodiadema whitneyi, n. sp. Plate 3, figs. 1a, 1b, 1c

Description.—Test circular in ambital outline, sides inflated and regularly curved; adactinal surface almost flat but slightly depressed near the peristome; abactinal surface depressed, convex.

The ambulacra are straight and narrow. They widen gently from 1 mm. at the discal opening to 2.5 mm. at the ambitus, then narrow down to 1.5 mm. at the peristome. They are composed of two rows of alternating plates. Each large plate consists of three parts each of which contains a pair of pores. The surface is ornamented with two rows of primary tubercles, about ten to each row. The tubercles are scrobiculate, crenulate, and perforate. Granules are scattered on the margins of the plates. The poriferous zones are wide. The pores are round, uniserial, and they become irregular upon approaching the peristome.

The interambulacra are about 3 mm. wide at the discal opening, 5.5 mm. at the ambitus, and 2.5 mm. at the peristome. They are composed of two rows of alternating plates, about eleven to each row. Each plate is ornamented with a scrobiculate, crenulate boss which bears a spherical, perforate mamelon. Granules are scattered on the outer margins of the plates.

The discal opening is large and subpentagonal to oval.. The margin is smooth and there is no posterior groove.

The peristome is small, decagonal, and is marked by ten moderately developed branchial incisions. The lips of the interambulacra are about three times as wide as those of the ambulacra.

Related forms.—This species does not appear to be closely related to any yet described. It may be readily distinguished from *Troçhotiara texana* (Roemer) which also occurs in the same formation by its subpentagonal to oval discal opening which has no posterior notch and by the structure of the ambulacral plates.

Dimensions.—Diameter at ambitus, 13 mm.; height, 6 mm.; discal opening, 6 mm.; peristome, 6 mm.

Occurrence.—Upper clays of the Walnut formation.

Locality.—Borrow pit on west side of road 1 mile north of Leander, Texas.

Order **EXOCYCLOIDA** Jackson
Suborder **HOLECTYPINA** Gregory
Family **PYGASTERIDAE** Gregory
Genus **HOLECTYPUS** Desor, 1842

Holectypus bullardi, n. sp. Plate 3, figs. 2a, 2b, 2c

Description.—The test is circular in ambital outline; ambitus sharp; abactinal surface elevated and regularly curved; adactinal surface almost flat near ambitus, but quite concave in the vicinity of the peristome.

The ambulacra are narrow and lanceolate. They widen gently from a point at the apical disk to 2 mm. at the ambitus then decrease in width upon approaching the peristome. The poriferous zones are narrow, the pores small, round, and uniserial. There are four vertical rows of tubercles in the area at the ambitus, which become reduced toward the poles.

The interambulacra are about twice the width of the ambulacra at the ambitus. The plates are long, narrow; each ornamented with a horizontal row of tubercles, about three to a row at the ambitus, but fewer above and below. The tubercles are small, perforate and finely crenulate.

The peristome is small and slightly decagonal; ambulacral and interambulacral lips practically equal.

The apical system is small and elevated slightly above the surface of the shell. It is composed of five ocular and five genital plates. The genitals are long, pointed, and are perforated near their outer margins. The right anterior genital is enlarged and modified to form the madreporite which extends to the center of the system. The oculars are quite indistinct but triangular in shape.

The periproct is quite large and is situated about midway between the peristome and ambitus. Both ends of the periproct are pointed but the anterior end is very slightly rounded in some specimens.

Related forms.—This species has a slight resemblance to *Holectypus hondoënsis* Cannon from the Anacacho formation, but it may be readily distinguished by its circular ambital outline and the shape of the periproct.

Dimensions.—Diameter at ambitus, 9 mm.; height 4.7 mm.; peristome, 2 mm.; length of periproct, 2 mm.; width of same 1.2 mm.

Occurrence.—Austin formation. About the *Terebratulina guadalupæ* zone.

Locality.—On Little Walnut Creek south of old iron bridge on road from Austin to Sprinkle, Texas.

Holectypus hondoënsis Cannon, n. sp. Plate 3, figs. 3a, 3b, 3c

Description.—Test sub-pentagonal almost circular, subconical, adoral surface flat, depressed at the peristome, sides regularly curved, ambitus near the adoral surface.

The apical disk is small, pentagonal (?). The details are not distinguishable on our specimen.

The ambulacral areas are straight, narrow, widest at the ambitus. The primary plates bear two pairs of pores on one primary tubercle. Each tubercle is in a relatively wide areola which in turn is surrounded by fine granules. The pores are small, circular and unigeminal.

The interambulacral areas are about twice the width of the ambulacral. The primary plates are long, narrow, and supplied with 3 rows of primary tubercles. Each tubercle has a wide areola which in turn is surrounded by fine granules.

The peristome is small, depressed, and having slight branchial incisions which give it a decagonal margin.

The periproct is oval, being about twice as long as wide, situated on the flat adoral surface about equally distant from peristome and ambitus.

Dimensions.—Height, 8 mm.; diameter, 13 mm.

Remarks.—This species bears certain resemblances to *Holectypus planatus* Roemer, but differs by having only two rows of tubercles in the ambulacral areas, six in the interambulacral areas, and having a much smaller periproct.

Occurrence.—Basal chalky marl at King's Water Hole on Hondo River about 2 miles north of Hondo, Texas.

Suborder **SPATANGINA** Jackson
Tribe **CASSIDULOIDEA** Duncan
Family **ECHINONEIDAE** Wright
Subfamily **ECHINONEINAE** Desor
Genus **PYRINA** Desmoulins, 1835

Pyrina whitneyæ, n. sp. Plate 3, figs. 4a, 4b, 4c

Description.—The test is circular in outline at the ambitus;

abactinal surface inflated and gently rounded; adactinal surface concave.

The ambulacral areas are straight, lanceolate, slightly widening from a point at the apical disk to 6 mm. at the ambitus, then narrowing down to 1.5 mm. at the peristome. The poriferous zones are straight and are composed of about one hundred and twenty-four rounded uniserial pores.

The interambulacral areas are wider than the ambulacral areas being 2 mm. wide in the plocogenous zone, about 15 mm. at the ambitus, then narrowing down to 2 mm. at the peristome. Both the ambulacral and interambulacral areas bear numerous primary tubercles which are in slight depressions. Very fine granules are disseminated between the primary tubercles.

The peristome is circular being somewhat elongated on the posterior-anterior axis and situated in the middle of the base.

The apical system is small being composed of four genital and five ocular plates. The right anterior genital plate has been modified to form the madreporitic opening. The two posterior oculars are in contact with each other but the anterior and lateral oculars are between the genitals.

The periproct is oval and is located on the lower portion of the posterior margin, the upper portion of the periproct being at about one-half of the height of the shell.

Related Forms.—This species presents a slight similarity to *Pyrina parryi* Hall in general appearance but it is more elevated, circular in outline and is more convex on the actinal surface. The shape of the peristome is more circular and the periproct is located lower on the posterior surface.

It may be distinguished from *Pyrina inaudita* Böse by the fact that the periproct is much lower.

It is more circular in outline than *Pyrina clarki* Böse.

Dimensions.—Length, 35 mm.; height, 20 mm.; width, 34 mm.; height of periproct, 7 mm.; width of same, 4 mm.

Occurrence.—Georgetown formation.

Locality.—East slope of Mount Bonnell west of Austin, Texas.

Subfamily ECHINOBRISSINAE Duncan

Genus NUCLEOLITES Lamarck, 1801

Nucleolites wilderæ, n. sp. Plate 3, figs. 5a, 5b, 5c

Description.—Test medium in size, subquadrate; adactinal surface slightly concave, abactinal surface depressed, convex. The greatest width of the shell is just anterior to the anal opening.

The ambulacral areas are short and lanceolate. They extend around to and are well developed in the region of the peristome. The poriferous zones on the upper surface are subpetaloid. The pores of the inner row are round whereas those of the outer row are slightly elongate and obliquely placed.

The interambulacral areas are broad and bear numerous small mamillated tubercles around which are located many minute granules. They widen gradually in size from the apical system until they reach the peristome where they end in a distinct lobe.

The apical system is small and is situated about one-third of the length of the shell from the anterior end. Four of the genital plates are pierced by large genital openings. The madreporite is large and centrally located.

The periproct is supramarginal, elongate, narrow, and is situated in the anterior end of a shallow groove. The anal sulcus almost totally disappears before reaching the posterior margin.

The peristome is small, pentagonal in shape, and is located slightly anterior of the center of the base. Extending posteriorly from the peristome to the margin of the shell is a broad band which is free from tubercles.

Related forms.—This species reminds one of *Echinobrissus texanus Clark* when viewed from above or below, but when viewed from the side it is unlike any other whose description has fallen under my observation. It is characterized by a long flat ridge on top and is not pointed as most other species.

Dimensions.—Length, 28 mm.; width, 24.5 mm.; height 13 mm.

Occurrence.—Austin formation—*Spondylus guadalupæ* zone.

Locality.—Travis Heights, Austin, Texas.

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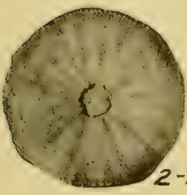
PLATES

PLATE I (4)

EXPLANATION OF PLATE 1 (4)

Figure Page

1. **Codiopsis sellardsi, n. sp.** 12
   a. Abactinal surface; b. lateral surface; c. adactinal surface; × 1
2. **Pedinopsis engerrandi, n. sp.** 14
   a. Abactinal surface; b. lateral surface; c. adactinal surface; × 1
3. **Pedinopsis yarboroughi, n. sp.** 14
   a. Abactinal surface; b. lateral surface; c. adactinal surface; × 1
4. **Salenia leanderensis, n. sp.** 16
   a. Abactinal surface; b. lateral surface; c. adactinal surface; × 4
5. **Salenia pseudowhitneyi, n. sp.** 17
   a. Abactinal surface; b. lateral surface; c. adactinal surface; × 1.5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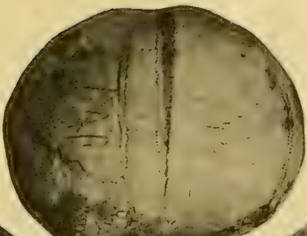
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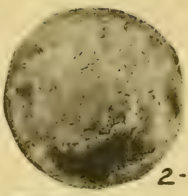
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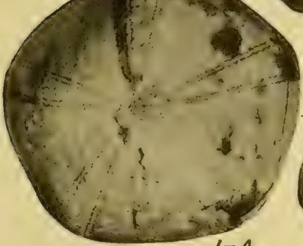
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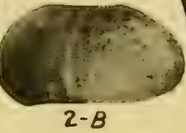
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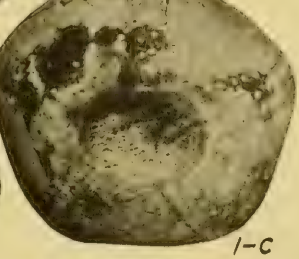
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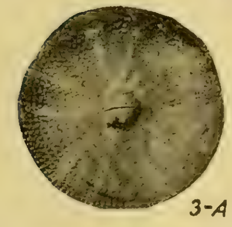
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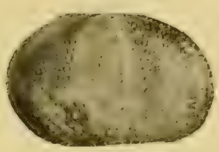
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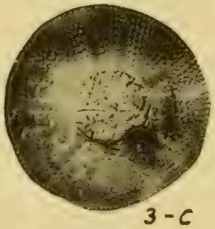
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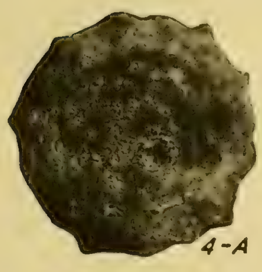
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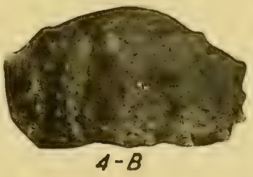
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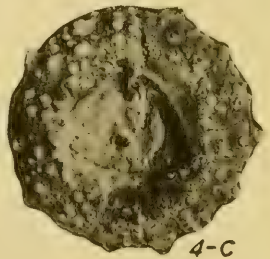
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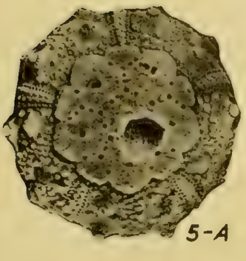
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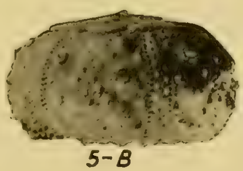
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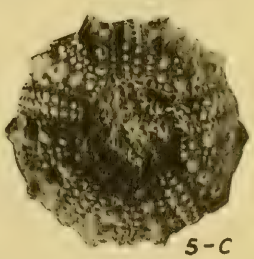
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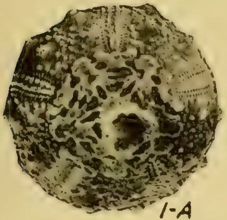
PLATE 2 (5)

EXPLANATION OF PLATE 2 (5)

Figure		Page
1.	**Salenia scotti,** n. sp. a. Abactinal surface; b. lateral surface; c. adactinal surface; × 1.5	18
2.	**Salenia stenzeli,** n. sp. a. Abactinal surface; b. lateral surface; c. adactinal surface; × 1.5	19
3.	**Salenia whitneyi** Cannon n. sp. a. Abactinal surface; b. lateral surface; c. adactinal surface; ×1	20
4.	**Goniophorus whitneyi,** n. sp. a. Abactinal surface; b. lateral surface; c. adactinal surface; ×4	21
5.	**Phymosoma bybeei,** n. sp. a. Abactinal surface; b. lateral surface; c. adactinal surface; ×1	23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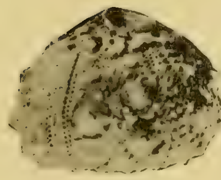
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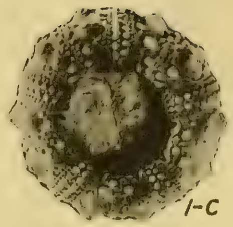
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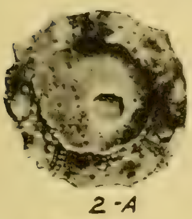
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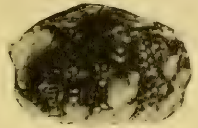
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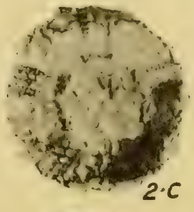
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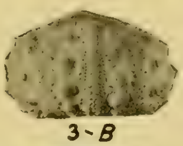
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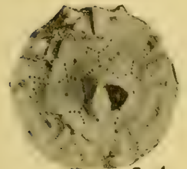
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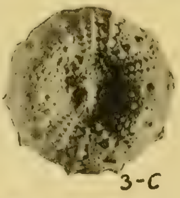
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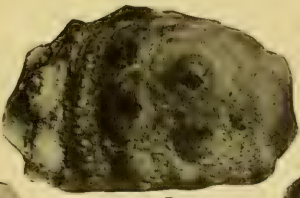
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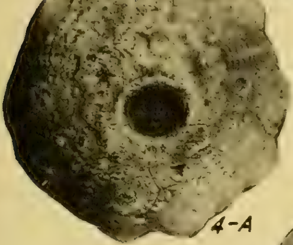
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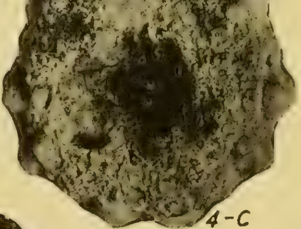
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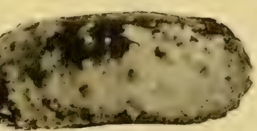
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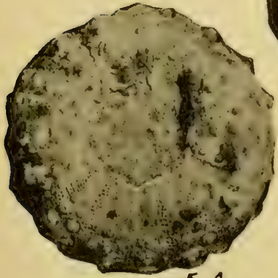
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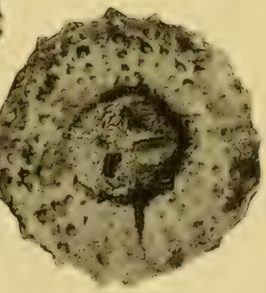
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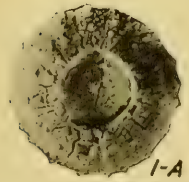
PLATE 3 (6)

EXPLANATION OF PLATE 3 (6)

Figure	Page
1. **Pseudodiadema whitneyi**, n. sp. a. Abactinal surface; b. lateral surface; c. adactinal surface; × 1.5	24
2. **Holectypus bullardi**, n. sp. a. Abactinal surface; b. lateral surface; c. adactinal surface; × 4	25
3. **Holectypus hondoënsis** Cannon n. sp. a. Abactinal surface; b. lateral surface; c. adactinal surface; × 2	26
4. **Pyrina whitneyæ**, n. sp. a. Abactinal surface; b. lateral surface; c. adactinal surface; × 1	26
5. **Nucleolites wilderæ**, n. sp. a. Abactinal surface; b. lateral surface; c. adactinal surface; × 1	26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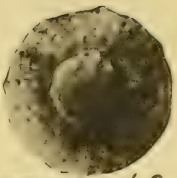
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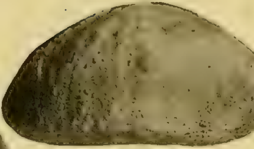
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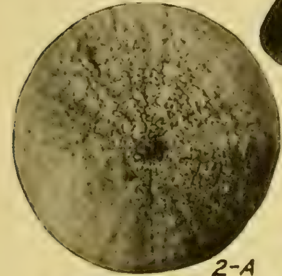
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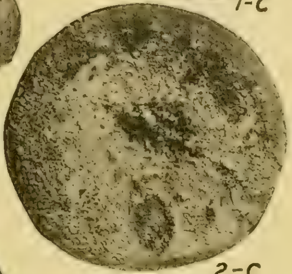
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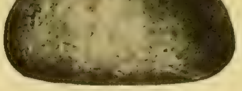
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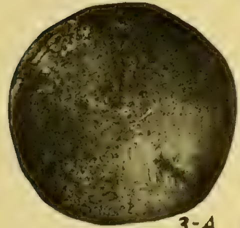
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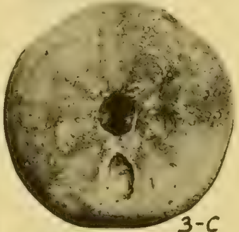
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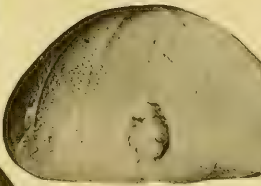
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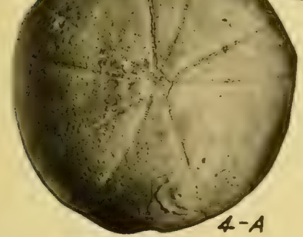
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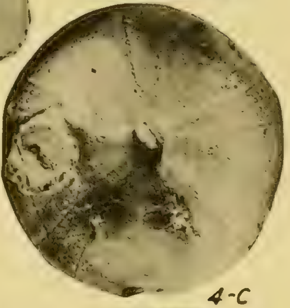
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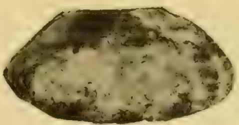
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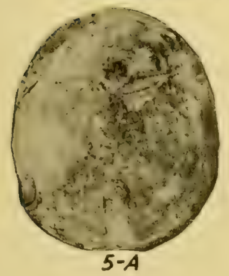
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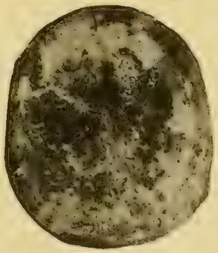
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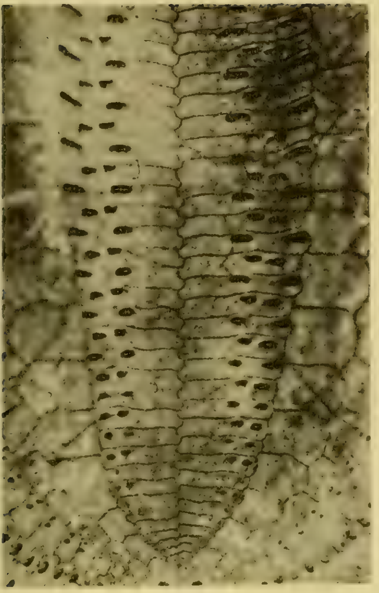
PLATE 4 (7)

EXPLANATION OF PLATE 4 (7)

Figure		Page
1.	**Enallaster texanus** (Roemer) a. Section of unpaired ambulacrum; b. section of left anterior paired ambulacrum; highly magnified	10
2.	**Heteraster oblongus** (Brongniart a. Section of unpaired ambulacrum; b. section of left anterior paired ambulacrum; highly magnified	10



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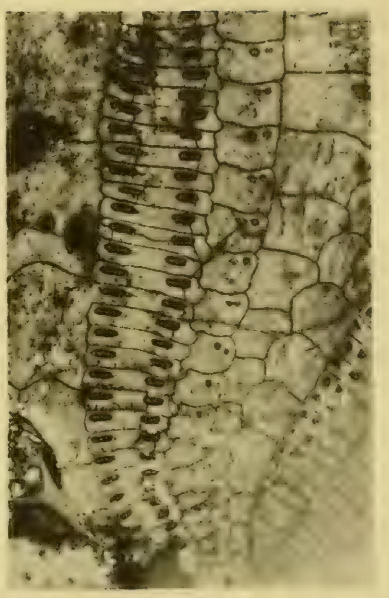

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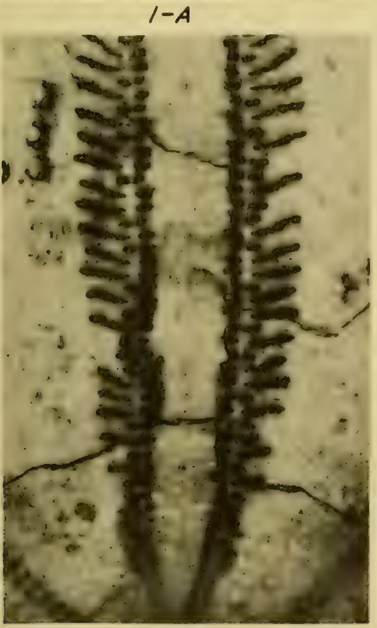

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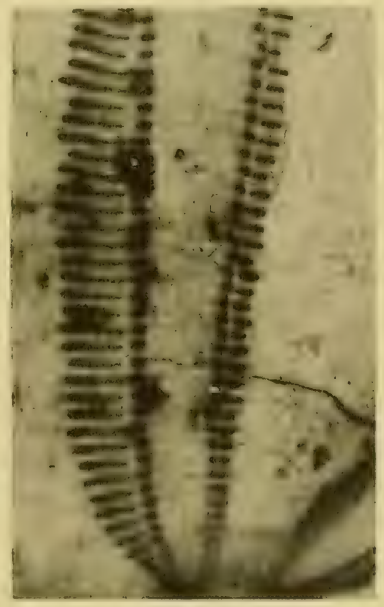

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Some New Crinoid Species from the Morrow Subseries

By
Harrell L. Strimple

January 11, 1940

Paleontological Research Institution
Ithaca, New York
U. S. A.

SOME NEW CRINOIDS FROM THE MORROW SUBSERIES

By

HARRELL L. STRIMPLE

INTRODUCTION

For additional knowledge of Morrow crinoids we are deeply obligated to Mr. Audd Dailey of Holdenville, Oklahoma. Mr. Dailey has with much patience, found a little known crinoid bed near Fittstown, Oklahoma, conducted the author and his wife, Mrs. Melba Strimple, to the locale for collecting, and placed his collection at the disposal of the author. It is most fortunate that Mr. Dailey has taken such a strong interest in Paleontology, and recognizes the advisability of presenting his important findings to science.

Presented herein is a more or less preliminary report on the new forms observed to date. Of course it is understood that consistent collecting, over a long period of time, will bring to light many more forms than now known. It is hoped that eventually we will have a more comprehensive selection of these rare Morrow crinoids.

DESCRIPTION OF SPECIES

Family **ICHTHYOCRINIDÆ** Angelin

(Emend. Wachsmuth and Springer)

Genus **AMPHICRINUS** Springer

Amphicrinus divergens, n. sp. Plate 1, figs. 11, 12

Calyx shallow, expanding rapidly; diameter, 10 mm.; height, 4 mm. Proximal columnal is in place so that presence or absence of IBB not known; BB five, protruding well out from under proximal columnal, that of the posterior no longer than others and truncated for the reception of anal X; RR low wide plates; seven-sided save those of the posterior which are six-sided; IBr^1 either five- or six-sided, low wide plates; IBr^2 are axillary and five-sided. That of the an-

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terior is strongly encroached upon to the left by a comparatively large interbrachial. The iBr^1, where preserved, are small hexagonal plates followed by two. In those rays preserved the arms appear to branch again with the IIBr^3. Anal X is rather large, five-sided, followed by a single plate. The upper extremity has a diagonal slant so that the left side is considerably higher than the right. This plate readily distinguishes the species from other known forms.

Occurrence and horizon.—Morrow subseries (limey blue shale just above the Caney shale formation), Pennsylvanian period; 6 miles SE of Fittstown, Oklahoma.

Type.—Springer Collection of the U. S. National Museum. Collected by Mrs. Melba Strimple.

Family **CATILLOCRINIDÆ** Wachsmuth and Springer

Genus **CATILLOCRINUS** (Troost) Shumard

Catillocrinus morrowensis, n. sp. Plate 1, figs. 7-10

Cup high, bowl-shaped; largest observed measures 6 mm., high; 10 mm., diameter. Basal disk low, occupied in the main by large columnar scar. Sutures not discernable in large figured specimen, but in the smaller, three unequal elements are observed, the smaller being posterior in position. The majority of the cup is composed of very large, unequal radials. R. post. R and l. ant. R are small; each faceted for the reception of a single, comparatively large arm; that of the r. post. having a small raised process for the reception of anal X; and the upper extremities of both are strongly encroached upon by adjoining RR, particularly the right shoulder of r. post. R which supports a long, narrow extension of the r. ant. R. The other three RR are large, expanding strongly, and sharply flared laterally at the upper extremities. In the largest observed specimen the r. ant. R is faceted for the reception of 12 arms, l. post. R, 9 arms, and the largest, ant. R, 15 arms. The articular facets are identical with other known *Catillocrinus.* The median portion of RR are decidedly tumid, giving the specimens a pentalobate appearance when viewed from below. The calyx pattern is similar to *C. carpenteri,* and *C.*

scoticus, which is to be expected since these species are closest stratigraphically. It is to be noted, however, that these species do not follow the calyx pattern that is typical of *Catillocrinus.*

Surface of cup is sprinkled with minute granulations.

Occurrence and horizon.—Morrow subseries, Pennsylvanian period; 6 miles SE of Fittstown, Oklahoma.

Types.—Springer Collection of the U. S. National Museum. Collected by H. L. Strimple.

Family POTERIOCRINTIDÆ Bassler

Genus HYDREIONOCRINUS de Koninck

Hydreionocrinus daileyi, n. sp. Plate 1, figs. 4-6

Calyx very shallow, saucer-shaped; height, 6 mm.; maximum diameter, 16.5 mm. Basal depression small, not very deep; IBB 5, small, equal elements comprising the floor of basal depression; BB 5, large, hexagonal elements, lower extremities curved under to form walls of basal depression, main portion of plates resting horizontally; post. B truncated for reception of anal X, and r. post. B for reception of radianal; RR 5, pentagonal, wider than high, median portions protruded outward and slightly downward as large spatulate-shaped protuberances. Articular facets developed slightly upward as wide shelves. To the fore is a sharp ligamental furrow, backed by a narrow cross ridge which is broken in mid-section by a v-shaped notch. Ambulacral notch only slight; muscle scars shallow, developed laterally. Anal X is rather small, pentagonal, resting solidly on post. B well within the cup. Radianal rather large, elongate, pentagonal. Right tube plate very long, six-sided, curving strongly inward so that the upper facet forms a horizontal plane with the quadrangular azygous plate resting on the anal X.

Columnar scar is small, round, heavily crenulated, and pierced by a minute round axial canal.

Surface of calyx plates are smooth.

The spectacular spatulate protuberance of the RR and distinct anal pyramid distinguishes this species from other known forms. If the factor of shallow and deep cups were established as sufficient for generic separation, this species could be assigned to *Plaxocrinus* Moore and Plummer, but unfortunately the author has at hand growth stages, from a higher horizon, that show some species of these forms have a deep calyx when young and are yet very shallow in maturity. Pending a more comprehensive understanding of these forms there seems to be no alternative but to assign them to *Hydreionocrinus*.

Occurrence and horizon.—Morrow subseries, Pennsylvanian period; 6 miles SE of Fittstown, Oklahoma.

Type.—Springer Collection of the U. S. National Museum. Collected by Mr. Audd Dailey of Holdenville, Oklahoma.

Genus **ETHELOCRINUS** Kirk

Ethelocrinus oklahomensis Moore and Plummer Plate 1, figs. 1-3

Ethelocrinus oklahomensis Moore and Plummer, 1938, Denison Univ. Bull., Journ. Sci. Lab., vol. 32, p. 256.

There is at hand a complete set of magnificent arms of *E. oklahomensis.* The calyx was hopelessly smashed in preservation and all plates not saved, but there is fortunately enough remaining to definitely establish the species. The post. B shows the presence of the large radianal in addition to the anal X. Two IBB plates, devoid of ornamentation, show the flattened basal disk. Normal, well preserved, heavily ornamented RR and BB conclude the identification.

The arms are massive, numbering ten, branching once on the primibrachs, and are thought to be approximating their maximum length, measuring 62 mm. long., with a mean width of around 8 mm.; strongly rounded backs and very thick. Pinnules not so large as would be expected. Primibrachs are large, wide, and heavily ornamented, knoblike protuberance just below the apex, and followed by two stout, low brachials. Those brachials following are ornamented, low, interlocking plates up to about mid-length of the arms where, for some unknown reason, the arms start to swell and protrude, climaxing with sometimes a right, sometimes a left brachial becoming even larger and developing into a massive spine. Some of the plates adjoining develop smaller spines. After climaxing the arms rapidly return to normal appearance, although the width is more slowly lost. Upper brachials are not pronouncedly ornamented.

Occurrence and horizon.—Morrow subseries (limey blue shale just above the Caney shale formation), Pennsylvanian period; 6 miles SE of Fittstown, Oklahoma.

Figured specimen.—Springer Collection of the U. S. National Museum. Collected by Mr. Audd Dailey of Holdenville, Oklahoma.

Genus **DELOCRINUS** Miller and Gurley

Delocrinus convexus, n. sp. Plate 1, figs. 13, 14

Cup low, bowl-shaped; height, 5.5 mm.; diameter, 12 mm.; base is gently convex or flattened; IBB five, small, equal elements; BB five, large, hexagonal plates, well rounded to participate in the basal convexity; post. B truncated for the reception of anal X; RR five, large, regular elements, slightly wider than high. Arm articular facets developed inward as horizontal shelves, notched to the fore by sharp ligamental furrow, backed by low cross ridge. Anal X rather elongate, resting solidly on post. B, half in half out of cup, hexagonal-shaped, followed apparently by a single anal plate. Of the arms there are only a few brachials preserved, the r. ant. IB^1 is in place and proves to be low, wide, and nonaxillary.

Columnar scar is small, round, heavily crenulated, and pierced by a minute, round, axial canal.

This species is obviously not a true *Delocrinus,* but neither does it follow the characteristics of other known forms. Pending a more comprehensive knowledge of the arms it seems best to place it under *Delocrinus.*

Occurrence and horizon.—Morrow subseries (limey blue shale just above the Caney shale formation), Pennsylvanian period; 6 miles SE of Fittstown, Oklahoma.

Type.—Springer Collection of the U. S. National Museum. Collected by Mr. Audd Dailey of Holdenville, Oklahoma.

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PLATE 1 (8)

EXPLANATION OF PLATE 1* (8)

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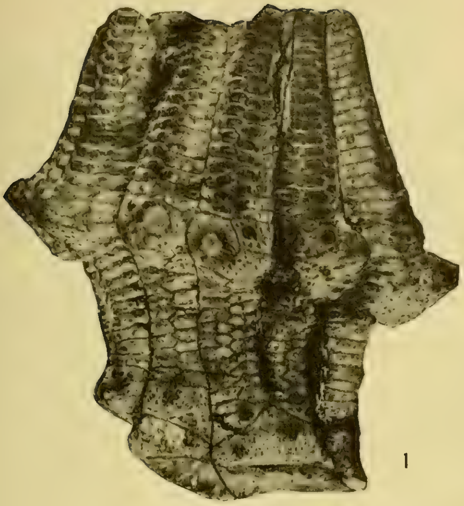
* Figure 1 natural size, all others ×2.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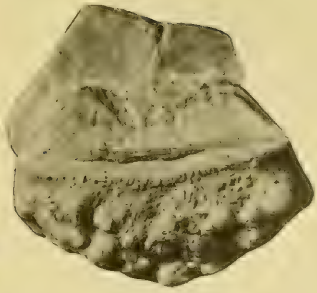
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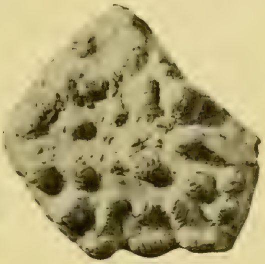
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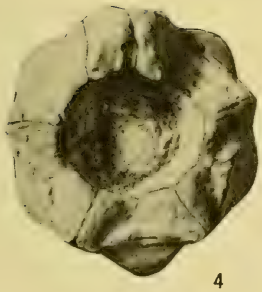
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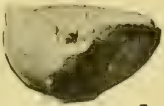
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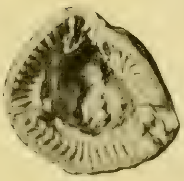
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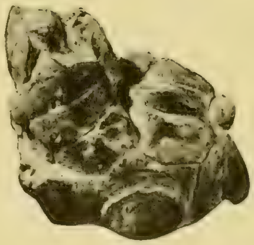
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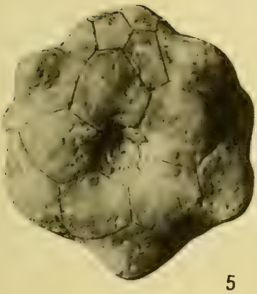
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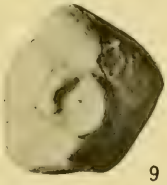
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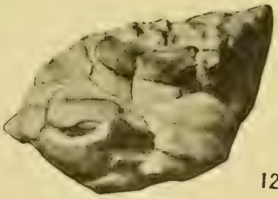
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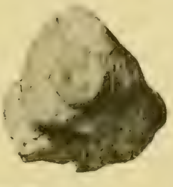
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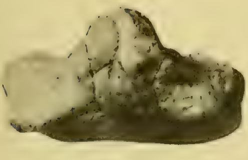
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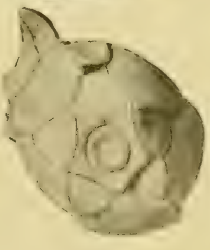
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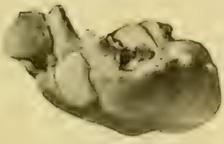
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Four New Crinoid Species from the Wewoka Formation And Two from the Ochelata Group

By

Harrell L. Strimple

January 15, 1940

Paleontological Research Institution
Ithaca, New York
U. S. A.

FOUR NEW CRINOID SPECIES FROM THE WEWOKA FORMATION AND TWO FROM THE OCHELATA GROUP

By

HARRELL L. STRIMPLE

INTRODUCTION

For our knowledge of crinoids from the Wewoka formation, we are deeply indebted to Mr. Audd Dailey, of Holdenville, Oklahoma, who has been kind enough to place his collection at the disposal of the author. These forms will form a valuable link between the lower and upper Pennsylvanian, which has hitherto been practically unknown. Mrs. R. I. Pound, of Bartlesville, Oklahoma, contributed the excellent specimen of *Amphicrinus.*

The form herein described as *Euonychocrinus dubius,* n. g., n. sp., has been known to us for some time, but not until recently was the excellent specimen, figured subsequently, found by my wife, Mrs. Melba Strimple.

DESCRIPTION OF SPECIES

Order **FLEXIBILIA** Zittel

Family **ICHTHYOCRINIDÆ** Angelin

(Emend. Wachsmuth and Springer)

Genus **EUONYCHOCRINUS,** n. g.

A cursory examination of the form at hand discloses that it is quite different from other known Pennsylvanian Flexibilia. The horizontal development of the arms certainly reminds one of the Mississippian *Onychocrinus,* but since it is hardly possible that the genus would survive such a long lapse of time without any intermediate forms, and in fact since the form at hand is distinct within itself, it is deemed advisable to propose a genus for its reception, *Euonychocrinus,* n. g., seeming appropriate.

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Generic description.—Cup low, expanding rather rapidly; IBB (if present), and most of five BB covered by wide proximal columnals; post. B larger than other BB, and truncated for reception of anal X; RR five, low, wide elements, articular facets for reception of arms developed almost horizontally; anal X quadrangular, developed inward; interbrachials four, small, elongated elements. Of the arms our knowledge is limited to the first few brachials, which are developed strongly outward, taper considerably, and have strongly rounded backs.

Genotype.—*Euonychocrinus dubius,* n. g., n. sp.

Occurrence and horizon.—Pennsylvanian; North America.

Euonychocrinus dubius, n. sp. Plate 1, figs. 11-13

Cup low, expanding rapidly; diameter, 9.3 mm.; height, 2.5 mm.; large, columnar scar covering IBB (if present) and most of the BB; post. B considerably longer and wider than other BB, and is truncated for the reception of anal X; RR five, rather large, wide, pentagonal elements; that of the l. post. is developed strongly inward to form a support for the anal X and in fact participates in forming a portion of the wall for the ambulacral groove of the l. post. arm; articular facets developed outward; anal X large quadrangular element, broadly truncated for the reception of a single azygous piece, developed inward at right angles with the horizontal arms, and outward facing articular facet of post. B; first interbrachials four, there being no r. post. in position, elongated, slightly above mid-height suddenly sharply notched, apparently for the reception of very narrow secondary pieces, upper extremity truncated for reception of a single plate, these plates are developed slightly outward at an angle between the almost horizontal arms, and the almost vertical anal X. Of the arms our knowledge is limited to the first few brachials, which are rather stout, considerably narrower than the RR, rounded backs yet with wide shallow ambulacral grooves.

Tegmen unknown.

Proximal columnals are very thin, wide, round, lightly crenulated about the perimeter, and pierced by a minute axial canal.

Holotype.—Springer Collection, U. S. National Museum. Collected by Mrs. Melba Strimple.

Occurrence and horizon.—Stanton limestone member, Missouri series, (Ochelata group), Pennsylvanian; near Wayside, Kansas. Comparatively common.

Amphicrinus simplex, n. sp. **Plate 1, fig. 1**

Cup low, expanding rapidly; diameter, 16 mm.; height, 5 mm.; IBB (if present) and much of BB covered by large proximal columnal; BB five, extending well out from under proximal columnal, particularly that of the post. which is broadly truncated for the reception of anal X; RR five, low, wide plates, those of the posterior being six-sided, others seven-sided; anal X large, six-sided, followed by a small, narrow, elongated secondary piece to the left, faceted for the reception of a large azygous plate above, the right shoulder is slightly dropped, but not so pronounced as in *A. divergens* Strimple; the small secondary azygous piece is followed by a small, four-sided piece, which is overhung by IBr^2. Of the arms our knowledge is limited to those of the l. post. and l. ant.; IBr^1 are low, wide, nonaxillary plates; IBr^2 are not quite so low, wide, axillary pieces, branching once, and no further evidence of branching through the $IIBr^2$ observed. Primary iBr observed are comparatively large, hexagonal plates, followed by two rather elongated, six-sided plates, third series composed of three, very narrow, elongated plates, the outer ones being five-sided, the middle hexagonal, fourth series composed of two elongated plates. Observed primary iIIBr elongated, hexagonal plate.

This form is quite distinct from other known species of *Amphicrinus* in the arrangement of azygous pieces together with the arrangement and number of primary iBr, and since it is from a horizon from which few crinoids have keen known, it seems advisable to erect a new species for its reception.

Holotype.—Springer Collection, U. S. National Museum. Collected by Mrs. R. I. Pound, of Bartlesville, Oklahoma.

Occurrence and horizon.—Wewoka formation, Pennsylvanian; near Holdenville, Oklahoma.

Order **INADUNATA** Wachsmuth and Springer

Suborder **FISTULATA** Wachsmuth and Springer

Family **POTERIOCRINITIDÆ** Bassler

Genus **SCYTALOCRINUS** Wachsmuth and Springer

Scytalocrinus pentacolumnus, n. sp. Plate 1, figs. 14, 15

Cup high, turbinate-shaped; IBB visible from side view; diameter, approximately 7.8 mm.; height, 6 mm.; IBB five, small regular elements; BB five, large six-sided elements, save that of the posterior which is truncated for the reception of anal X; RR five, large, pentagonal plates, slightly wider than high; anal X hexagonal, radianal pentagonal, right tube plate apparently six-sided, all three being approximately equal in size. All plates of the cup have scalloped appearing edges, so that a raised portion meets like occurrence on the adjoining plate.

Arms unobserved save for r. post. IBr[1], same being elongated, constricted in mid-section, and axillary. Tegmen unknown.

Proximal columnal is pentagonal, crenulated about the perimeter, and pierced by minute round axial canal.

Relationship.—The peculiar scalloped appearing edges of the plates, and the pentagonal stem, serve to distinguish this form from other known species.

Holotype.—Springer Collection, U. S. National Museum. Collected by Mr. Audd Dailey of Holdenville, Oklahoma.

Occurrence and horizon.—Wewoka formation, Pennsylvanian; near Holdenville, Oklahoma. Rare.

Genus **DELOCRINUS** Miller and Gurley

Delocrinus parinodosarius, n. sp. Plate 1, figs. 3, 5, 8

Cup low, bowl-shaped; diameter, 13 mm.; height, 4 mm.; funnel-shaped basal cavity; IBB five, small, confined to the basal cavity; BB five, large, six-sided save for that of the posterior which is truncated for the reception of the small anal X, lower extremity curved under to participate in basal concavity, elongated, shallow depression occupies median portion of plates; RR five, normal, wider than high, pentagonal elements, upper portion slightly protruded and occupied by a crescent-shaped row of nodes, above which the cup is constricted; anal X small, elongo-hexagonal, resting well within the cup, articular facet is shallow, rounded depression as is characteristic of *Delocrinus,* faceted for the reception of a single azygous plate.

The columnar scar is small, round, crenulated, and pierced by a minute star-shaped, axial canal.

The surface of the calyx is rough, but only those nodes on the RR are prominent. This feature, together with the shallow depressions of the BB constitute the main characteristics differentiating the species from other known forms.

Holotype.—Springer Collection, U. S. National Museum. Collected by Mr. Audd Dailey of Holdenville, Oklahoma.

Occurrence and horizon.—Wewoka formation, Pennsylvanian; near Holdenville, Oklahoma.

Delocrinus wewokaënsis, n. sp. Plate 1, figs. 2, 4, 6

Cup very low, saucer-shaped; diameter, 21 mm.; height, 7.5 mm.; funnel-shaped basal cavity, very wide; IBB five, small, equal elements confined to the bottom of the basal cavity; BB five, large, pentagonal elements, that of the posterior being six-sided by virtue of supporting anal X, lower portion curved under to form walls of basal concavity; RR five, large pentagonal, regular elements, articular facets developed inward as wide horizontal shelves; anal X rather large, elongo-hexagonal, resting well within cup; articular facet split for two secondary pieces, that facet to the left being larger and almost covering the entire surface to the fore, both of the facets being rather shallow, with the rim mildly crenulated. The cup is smooth.

Columnar scar is small, round, heavily crenulated and pierced by minute, star-shaped, axial canal.

Arms and tegman unknown.

Relationship.—This form is not a true *Delocrinus,* even though possessing most of the characteristics of one, due to the upper articular facet of the anal X. The form is not considered distinct enough to segregate generically, and is probably the immediate predecessor to that form known as *D. hemisphericus* (Shumard).

Holotype.—Springer Collection, U. S. National Museum. Collected by Mr. Audd Dailey of Holdenville, Oklahoma.

Occurrence and horizon.—Wewoka formation, Pennsylvanian; near Holdenville, Oklahoma. Comparatively common.

Genus **PENTADELOCRINUS** Strimple

Pentadelocrinus twinensis, n. sp. Plate 1, figs. 7, 9, 10

Cup rather low, bowl-shaped; diameter, 16 mm.; height, 6 mm.; base shallowly concave; IBB five, small, regular elements, extending well beyond the proximal columnal, and confined to the basal cavity; BB five, rather large, six-sided elements save that of the posterior which is seven-sided, being truncated for the reception of anal X, lower extremities curved under to participate in basal concavity, decidedly tumid and recurving at outer margins to form confluent ridges with adjoining pieces; BB five, large pentagonal elements, slightly wider than high, tumid, and recurving at the sutures, strong articular facets developed inward as wide, sloping shelves, strong ligamental furrow to the fore climaxed by a sharp deep notch in midsection, all well shown in the illustrations; anal X rather large, elongated, six-sided, resting well within the cup, and faceted for the reception of two azygous plates. Of the arms our knowledge is limited to the r. post. IBr^1, which is very low, and nonaxillary. All plates are very delicately granular. Tegmen unknown.

Proximal columnal is pentagonal, crenulated, and pierced by a minute axial canal.

Relationship.—This form is quite similar in general appearance to *Cibolocrinus regularis* Moore and Plummer, however, the presence of five IBB and a pentagonal stem eliminates even generic relationships. The species is quite distinct from *P. typus* Strimple in the tumidity of the plates, fuller calyx, granular surface, and in the recurving of the outer extremities of the calyx plates. *P. typus* is saucer-shaped, sutures regularly depressed and is smooth.

Holotype.—Springer Collection, U. S. National Museum. Collected by H. L. Strimple.

Occurrence and horizon.—"Gastropod" shale zone, Ochelata group, Pennsylvanian; "Twin Mounds" 5 miles SE of Ochelata, Oklahoma. Rare.

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EXPLANATION OF PLATE 1 (9)*

1. **Amphicrinus simplex,** n, sp. 5
Oblique side view of holotype. Wewoka formation, near Holdenville, Okla.

2, 4, 6. **Delocrinus wewokaënsis,** n. sp. 7
View from above, side view of posterior, and view from below; holotype. Wewoka formation, near Holdenville, Okla.

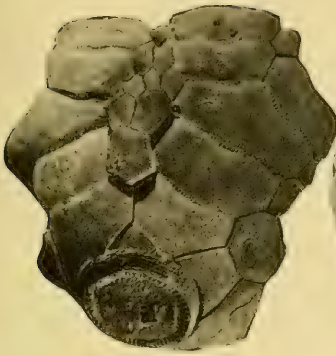
3, 5, 8. **Delocrinus parinodosarius,** n. sp. 6
View from below, view from above, and side view of posterior; holotype. Wewoka formation, near Holdenville, Okla.

7,9,10. **Pentadelocrinus twinensis,** n. sp. 8
Side view of posterior, slightly oblique view from below, and view from above; holotype. Ochelata group, "Twin Mounds" near Ochelata, Okla.

11-13. **Euonychocrinus dubius,** n. g., n. sp. 4
View from below, side view of posterior, and view from above; holotype. Stanton ls. member, Missouri series (Ochelata group), near Wayside, Kansas.

14, 15. **Scytalocrinus pentacolumnus,** n. sp. 6
Oblique anterior view, and view of posterior; holotype. Wewoka formation, near Holdenville, Okla.

* All figures enlarged ×2.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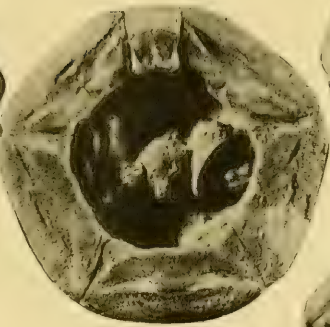
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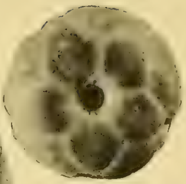
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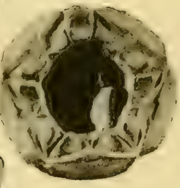
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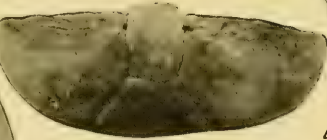
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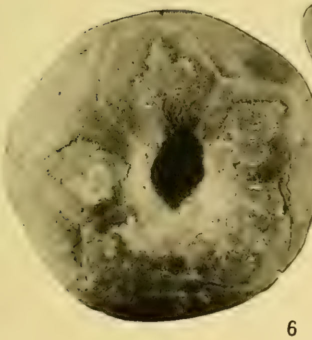
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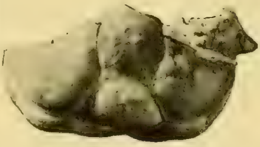
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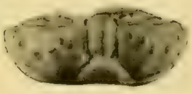
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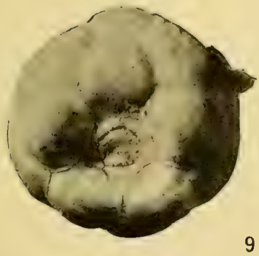
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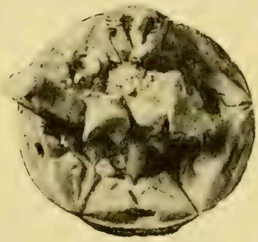
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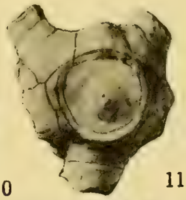
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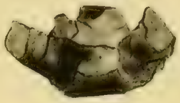
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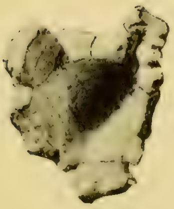
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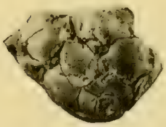
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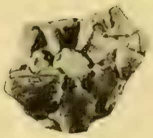
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ADDENDA

March 7, 1940

BULLETIN 92A

STELLAROCRINUS, NEW NAME FOR *WHITEOCRINUS* STRIMPLE

By

HARRELL L. STRIMPLE

ADDENDA

STELLAROCRINUS,
NEW NAME FOR *WHITEOCRINUS* STRIMPLE

By

HARRELL L. STRIMPLE

I described in these Bulletins[1], as a new genus, *Whiteocrinus,* to receive those Pennsylvanian crinoid forms typified by *Cyathocrinus stillativus* White, which species was taken as the genotype. It has been called to my attention that *Whiteocrinus* is a preoccupied name, having been used by Jaekel[2]. Therefore, I propose a new generic name, *Stellarocrinus,* with *Cyathocrinus stillativus* White as the genotype.

So far as known to the author, the only reference which has been made to *Whiteocrinus* Strimple (not Jaekel), subsequent to its inception has been by Moore[3].

This opportunity is taken to extend our knowledge of *Stellarocrinus stillativus* (White), and present a new species as *Stellarocrinus distinctus,* n. sp.

DESCRIPTION OF SPECIES

Order **INADUNATA** Wachsmuth and Springer
Suborder **FISTULATA** Wachsmuth and Springer
Family **CYATHOCRINIDÆ** Roemer
(Emend. Wachsmuth and Springer)
Genus **STELLAROCRINUS**, n. n.

Genotype.—*Cyathocrinus stillativus* White.

Stellarocrinus stillativus (White) Plate 1, figs. 1-4

Cyathocrinus stillativus White, 1880, Proc. Nat. Mus., vol. 2, p. 258; 1880, Geol. Surv. of the Territories, p. 125, pl. 35, figs. 3a, b.

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[1] Strimple, Harrell L.: Bull. Amer. Paleont., vol. 25, No. 89, August, 1939, p. 4.

[2] Jaekel, O.: Pal. Zeits., Bd., 3, 1918, p. 58.

[3] Moore, R. C.: Denison Univ. Bull., Journ. Sci. Lab., vol. 34, Art. 6, December, 1939, p. 180 (as a footnote).

MAR 25 1940

Cyathocrinus (?) *stillativus* Wachsmuth and Springer, 1886, Revision of the Palæocrinoidea, Part 3, Proc. Acad. Nat. Sci., Phila., p. 226.
Phialocrinus stillativus Keyes, 1894, Geol. Survey Missouri, vol. 4, p. 219, pl. 28, figs. 6a, b.
Whiteocrinus stillativus Strimple, 1939, Bull. Amer. Paleont., vol. 25, No. 89, p. 5, pl. 1, figs. 1, 2, 9.

The two specimens at hand warrant figuring in that one is very young, and unusually well preserved, the other being mature, with most of the anal sac well shown.

Immature specimen.—Cup low, with diameter of 6.4 mm.; height of 1.5 mm. (excluding articular facets). Arms are straplike, extending outward for a short distance, then abruptly coiling inward. Only ten arms noticed, and the extremities are thought to have been observed, approximate length, 15 mm., mean width, 3 mm.; IBr^1 elongated, median portion constricted, length, 3.1 mm.; subsequent Br low wide elements, incipiently interlocking. The tegmen is somewhat compressed, but is seen to be composed of stout, spiney plates, that which occupies the upper extremity pointing upward.

The cup is not so strongly ornamented as in more mature forms.

Mature specimen.—Diameter of calyx, 18.4 mm.; height to lower extremity of arm articular facet, 7.4 mm.; arms very fragmentary, measuring some 7 mm., wide, decidedly biserial, flat, straplike, branching once on IBr^1, said plates being 4.2 mm., long, by 7 mm., wide; tegmen not preserved in its entirety, but shown to be composed of circlets of stout, spinelike azygous plates. These plates are quite common in many of the middle Pennsylvanian formations.

Cup strongly ornamented as is characteristic of the species.

Comparison.—There is considerable change in ratio between height and width of calices, which is partially due to the strong protrusion of the RR in mature forms, and is not thought to be necessarily representative of the species. Normally the calyx loses height with maturity, in many other observed genera of this period. The IBr^1 are reduced from 3:3 (length:width) to 4:7. The ornamentation is stronger in maturity, which seems characteristic of these forms. There is no appreciable difference in the arms, save the transition from incipiently biserial arms to decidedly biserial arms, and possibly proportionately greater width in maturity.

Occurrence and horizon.—Immature specimen, Stanton limestone member, Missouri series, Pennsylvanian, near Wayside, Kansas. Mature specimen, Stanton limestone member, Ochelata group, Pennsylvanian, the mound just west of Bartlesville, Oklahoma.

Figured specimens.—Springer Collection, U. S. National Museum. Collected by Mr. and Mrs. H. L. Strimple.

Stellarocrinus distinctus, n. sp. Plate 1, fig. 5

Cup is high, bowl-shaped, measuring 4.1 mm., high (excluding articular facet), with maximum diameter of 8.9 mm. The arrangment is identical with that characteristic of the genus. The arms are known to branch once with the IBr^1 and again with about the IIBr^7, being at least 20 cuneiform arms; IBr^1 are elongated, measuring 5 mm., long, by 4 mm., wide (maximum); subsequent Br have rather rounded backs, save for those sides being larger, which are protruded as spines. It is possible that the arms might become more or less biserial with maturity, and it is certain that the IBr^1 will lose some of its length to width. The arms appear to be tapering considerably at their most extreme point, indicative of approximating their maximum length, where they measure some 17 mm. in length.

The column is composed of alternating expanded, round columnals. The tegmen is unknown.

Relationship.—The cup of this species is similar to *S. exsculptus* (Strimple)[4], differing mainly in that the two ridges of each R in *S. exsculptus* do not pass the sutures. Considering that the specimen at hand is young, we have observed that with this unusual genus the calyx ornamentation apparently becomes more spectacular with maturity, and in any eventuality the form is decidedly more sharply angular than the gently ornamented *S. exsculptus*. Of *S. stillativus* there is figured herein a specimen considerably younger than the form at hand, wherein we have flat, incipiently biserial arms, as against the well rounded, cuneiform

[4] *Idem*: p. 5, pl. 1, figs. 7, 8.

20 arms of *S. distinctus*. In the fully mature form of *S. distinctus* we are certain to find some strong evidence of the spiney Br, as well as the early branching of the arms for the second time.

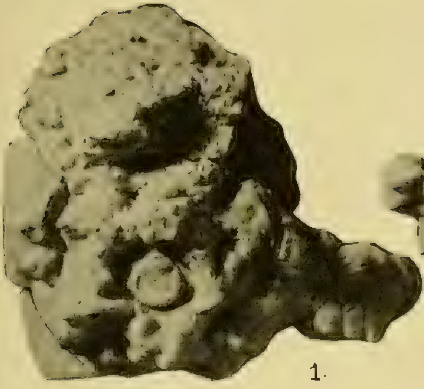
Occurrence and horizon.—Stanton limestone member, Ochelata group, Pennsylvanian, the mound just west of Bartlesville, Oklahoma.

Holotype.—Springer Collection, U. S. National Museum. Collected by H. L. Strimple.

EXPLANATION OF PLATE 1 (10)*

Figure		Page
1, 2.	**Stellarocrinus stillativus** (White) Fully mature specimen. View from below of cup, partially obliterated by matrix, and side view showing exposed tegmen. Stanton limestone member, Ochelata group, Pennsylvanian, just west of city limits of Bartlesville, Oklahoma.	1
3, 4.	**Stellarocrinus stillativus** (White) Immature specimen. View from below (anterior), and view from above. Stanton limestone member, Missouri series, Pennsylvanian, near Wayside, Kansas.	1
5.	**Stellarocrinus distinctus**, n. sp. Oblique anterior view. Stanton limestone member, Ochelata group, Pennsylvanian, just west of city limits of Bartlesville, Oklahoma.	3

* All figures approx. ×2.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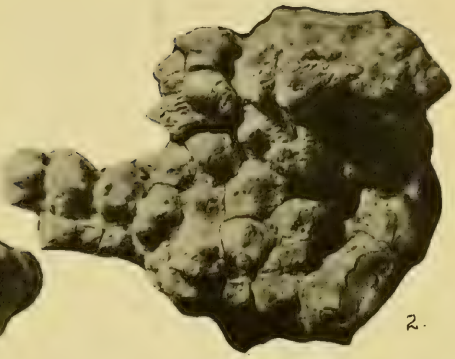
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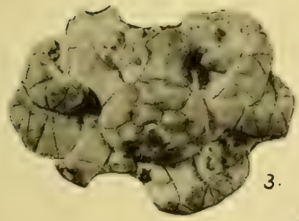
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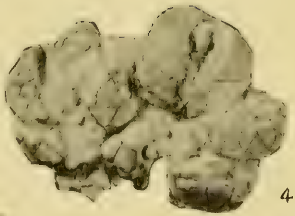
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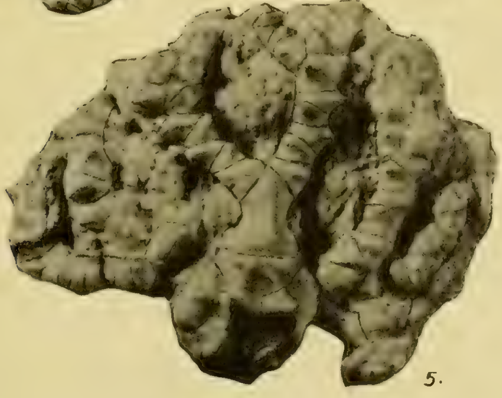
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Devonian Bryozoa from Colombia

By
Andrew H. McNair

June 8, 1940

Paleontological Research Institution
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DEVONIAN BRYOZOA FROM COLOMBIA

By

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Dartmouth College

ABSTRACT

A description of the Bryozoa from the Middle Devonian Floresta series of the State of Colombia, South America, is the purpose of this paper. Twenty-four new species are described. Although all of the species found in the fauna are new, they indicate strong relationship to the Middle Devonian bryozoans of eastern North America and therefore show that the Floresta fauna is probably ''boreal'' rather than ''austral'' in origin and relationship. A description is given of the method used in photographing the specimens, all of which were preserved as impressions in soft shales.

INTRODUCTION

The specimens described in this paper were made available for study through the kindness of Dr. Kenneth E. Caster. They are a part of a fauna discovered by Mr. Axel Olsson and Dr. Parke A. Dickey in 1935, from the Floresta series of the State of Colombia. The coöperation of these men and the International Petroleum Company by whom they were employed has made this study possible. The fossils of the collection, other than bryozoans, have been described by Caster (1939). The present paper completes the description of the large and varied collection of Olsson and Dickey. The author wishes to express his appreciation to the men who have aided him, either directly or indirectly, during the course of this study. He is especially indebted to Professor G. D. Harris and the Paleontological Research Institution for facilities of publication.

The fauna described here was collected from the Floresta series of Colombia, at exposures on the automobile road between Santa Rosa and Corales in the western part of the Departmento de Boyaca. A description of the locality and a discussion of the stratigraphic relationships of the Floresta series has been given by Caster, 1939 (pp. 9-10).

The types and other material on which this study is based are on deposit at the Paleontological Research Institution, Ithaca, New York.

RELATIONSHIPS AND AGE OF THE FAUNA

A study of the Bryozoa of the Floresta fauna confirms Caster's conclusion concerning the "boreal" relationships of the fauna. This is especially true of the genera of bryozoans in the collection which have been found only rarely in the Devonian strata of eastern North America, for example, the genera: *Tæniopora, Prismopora, Unitrypa* and to lesser degree, *Semicoscinium.* The following species described in this paper can be compared with Middle Devonian species of eastern North America: *Cyclotrypa stellata,* n. sp., *C. boyaca,* n. sp., *C. dickeyi,* n. sp., *Intrapora megalopora,* n. sp., *Fenestrellina colombiana,* n. sp., *F. harrisi,* n. sp., *Sulcoretepora subramosa,* n. sp., *S. olssoni,* n. sp., and *Tæniopora florestæ,* n. sp.

The Bryozoa do not add a great deal of information concerning the age of the fauna, the chief reason for this is that all of the species found in it are new. However, a strong similarity is to be seen between the Floresta Bryozoa and the Middle Devonian forms of North America. Most of the affinities appear to be with Hamilton Bryozoa. This may be accounted for, in part, by the fact that Hamilton Bryozoa are better known than those from earlier Middle Devonian strata. Caster, 1939 (p. 15) from a tabulation of species (including one bryozoan) came to the conclusion that the fauna most clearly resembled the early Onondaga of the North American Devonian.

METHOD OF STUDY AND REPRODUCTION OF SPECIMENS

The specimens collected at Floresta are preserved in soft, yellowish to buff colored shales which contained at the time of deposition considerable amounts of calcium carbonate. The calcium carbonate of the shales and the fossils has been leached, leaving a porous shale matrix containing only impressions of fossils. The fossils were covered by an iron oxide film so that their surfaces were imperfectly exposed. This film was removed by boiling the specimens several times in dilute hydrochloric acid to which small amounts of stannous chloride had been added. The impressions thus treated show considerable surface detail.

A number of methods were attempted to make casts of the specimens. Plasticine, dental wax and liquid rubber were used without success. Plasticine did not record surface detail that could be enlarged sufficiently to make photomicrographs. The other materials used in casting broke off surfaces of the impressions when the casts were pulled. Hardening the impressions in bakelite, canada balsam and celluloid cement covered surface details. Finally, the following method was devised to first study the specimens for identification and description and then to prepare the figures for plates.

Specimens that were selected for study were coated with a thin film of ammonium chloride to accentuate surface structures. Then they were photographed in evenly distributed light producing negatives of the impressions at a magnification of three and a half times. The negatives were contact printed on cut film, producing positives. The positives were enlarged on paper to make the desired sized figures. The reverse lighting produced by printing the final figures from positive film changed the impressions of the specimens so that they appeared as raised structures. The apertures, fenestrules and other deep depressions were then blackened with india ink. The chief disadvantage with the method is that the figures appear flatter than they actually are. Care must be taken when the specimens are first photographed that they do not have deep shadows because such areas will not show detail as high-lighted areas when the final print is made.

The method described above apparently can be used to photograph any type of impression and seems to be the most satisfactory method to use in making figures of delicate impressions that are preserved in friable shales.

DESCRIPTION OF BRYOZOA

Order **CYCLOSTOMATA** Busk
Suborder **CERAMOPORIDEA** Bassler
Family **FISTULIPORIDÆ** Ulrich
Genus **CYCLOTRYPA** Ulrich

Cyclotrypa stellata, n. sp. Plate 1, figs. 1, 5

Zoarium unilamellate; with a wrinkled, striated epitheca. Apertures subcircular to oval in outline; average diameter 0.2 mm.; surrounded by elevated peristomes; arranged in irregular lines radiating from maculæ; closer spaced and smaller nearest maculæ. Distance between lines from two to three times greater than diameter of apertures. Maculæ approximately 5 mm. apart; circular to elliptical in outline and only slightly depressed below surface; occupied by numerous short, rounded projections which also occur in limited numbers in lines between zoœcia.

Remarks.—This species is tentatively placed in the genus *Cyclotrypa.* Lack of internal structure forbids positive assignment. Externally it resembles *Fistulipora* (*Cyclotrypa?*) *granifera* Hall and in some respects *Fistulipora* (*Cyclotrypa?*) *corrugata* Ulrich. It differs from both, however, in having weaker spines in the maculæ.

Types.—Holotype: Pal. Res. Inst. No. 5879; paratype: 5882.

Cyclotrypa boyaca, n. sp. Plate 1, figs. 2, 3

Zoarium unilamellate; with a wrinkled, striated epitheca. Apertures oblique, subcircular to oval in outline; average diameter 0.2 mm.; surrounded by elevated peristomes; arranged in regular lines extending outward from sides of maculæ and in slightly less regular oblique lines, so that intersecting ranges of apertures are formed; largest and most elliptical near margins of maculæ; separated from each other by spaces from one to three times diameters of apertures. Maculæ irregularly spaced; usually elongate; slightly depressed beneath surface of zoaria; minute spines absent. Peristomes slightly elevated on sides of apertures nearest maculæ. Interapertural spaces occupied by occasional small, rounded spines.

Remarks.—This species is also tentatively placed in the genus *Cyclotrypa.* Several specimens studied exhibit vesicular tissue in the maculæ and interapertural spaces and thus show affinity of the species to the Fistuliporidæ. *Cyclotrypa boyaca* can be distinguished from *C. stellata,* n. sp. by the regularly spaced apertures and by the absence of spines in the maculæ.

Type.—Holotype: Pal. Res. Inst. No. 5880; paratype: 5881.

Cyclotrypa carribeana, n. sp. Plate 1, figs. 4, 6

Zoarium unilamellate; with a wrinkled, striated epitheca. Apertures oblique, subcircular to oval in outline; average diameter 0.16 mm.; surrounded by elevated peristomes; arranged in short irregular lines radiating outward from maculæ; largest near margins of maculæ; separated from each other by spaces from one to four times diameters of apertures. Maculæ irregularly spaced; usually elongate; four to five times longer than wide; surface smooth, not occupied by spines; slightly depressed below surface of zoarium; consisting internally of crowded vesicles. Interaperatural spaces smooth, slightly depressed.

Remarks.—*Cyclotrypa carribeana* is distinguished from *C. stellata,* n. sp. and *C. boyaca,* n. sp. by absence of spines in maculæ and in ranges of zoœcia and by the fact that the zoœcial apertures are largest near the margins of maculæ.

Types.—Holotype: Pal. Res. Inst. No. 5884; paratype: 5883.

Cyclotrypa dickeyi, n. sp. Plate 2, fig. 2

Zoarium unilamellate. Apertures circular in outline; average diameter 0.31 mm.; surrounded by strong peristomes; arranged in irregular lines extending outward from maculæ; slightly larger at margins of maculæ and smaller between maculæ; separated by spaces less than or equal to diameters of apertures. Maculæ roughly star-shaped; with four to six rays extending into areas between maculæ; depressed below surface of zoarium; not occupied by spines. Lunaria absent. Apertures on margin of maculæ sometimes oblique.

Remarks.—*Cyclotrypa dickeyi* can be distinguished from similar species in the fauna by its stellate maculæ and relatively large, far spaced, apertures. It differs from *C. collina* (Ulrich) of the "Hamilton" (Cedar Valley?) in having larger and more nearly oblique apertures.

Type.—Holotype: Pal. Res. Inst. No. 5886.

Cycloptrypa (?) reticulata, n. sp. Plate 2, fig. 5

Zoarium unilamellate; with a wrinkled, striated epitheca. Apertures elliptical to circular in outline; average diameter 0.16 mm.; surrounded by elevated peristomes; arranged in very irregular lines; distance between apertures two to three times diameter of apertures. Maculæ and lunaria apparently absent. Zoœcia prone along epitheca for a considerable distance and then bend abruptly upwards, opening directly at surface of zoarium. Interspaces occupied by straight-walled vesicles connecting adjacent zoœcia.

Remarks.—This is the only fistuliporoid in this fauna which shows any detail of internal structure. It can be distinguished from other fistuliporoids by the prominent straight-walled vesicles which are reflected on the surface of the zoarium.

Type.—Holotype: Pal. Res. Inst. No. 5889.

Genus **FISTULIPORA** McCoy

Fistulipora megalopora, n. sp. Plate 2, fig. 1

Zoarium unilamellate. Apertures subcircular to oval in outline; average diameter 0.4 mm.; surrounded by low, delicate peristomes; arranged in irregular lines extending outward from sides of maculæ; smallest near margins and largest and closest spaced between maculæ; separated by distances usually less than diameters of apertures. Maculæ spaced irregularly, elongate, smooth; depressed slightly below surface of zoarium. Peculiar circular impressions have been found within the zoœcial apertures, these structures appear to be crushed lunaria.

Remarks.—*Fistulipora megalopora,* n. sp. is easily distinguished from other fistuliporoids in the fauna by its large closely spaced apertures and by the presence of circular impressions in apertures.

Type.—Holotype: Pal. Res. Inst. No. 5885.

Fistulipora (?) anomala, n. sp. Plate 2, fig. 3

Zoarium unilamellate. Apertures irregular in outline; average diameter 0.3 mm.; not surrounded by peristomes; arranged irregularly; largest near margins of maculæ; smallest in spaces between maculæ; separated by distances less than diameter of apertures, partially closed on side nearest maculæ by prominent irregular lunaria. Maculæ much depressed; circular to elongate in outline; separated by intervals of 5 to 10 mm.

Remarks.—Lack of internal structures in the specimens studied does not allow definite generic assignment to this species. It differs from most species of *Fistulipora* because it lacks peristomes surrounding the apertures. It can be distinguished from other fistuliporoids in the fauna by its conspicuous lunaria. The maculæ are much more depressed than fig. 3, Plate 1, would indicate.

Type.—Holotype: Pal. Res. Inst. No. 5887.

Fistulipora (?) delicata, n. sp. Plate 2, fig. 4

Zoarium unilamellate. Apertures small, average diameter 0.12 mm.; opening directly or obliquely outward; surrounded by low peristomes; arranged in regular lines radiating outward from maculæ; largest in size and oblique to surface at margins of maculæ; smallest and opening directly outward in spaces between maculæ; separated by spaces greater than diameter of apertures. Lunaria prominent, usually indenting margin of apertures. Maculæ roughly circular in outline; slightly depressed below surface of zoarium; occupied by numerous small, short spines; spines also occur in spaces between apertures.

Remarks.—This species can be distinguished from other fistuliporoids in the fauna by its very minute oblique apertures, and its circular maculæ.

Type.—Holotype: Pal. Res. Inst. No. 5888.

Order **CRYPTOSTOMATA** Vine

Family **STITOPORELLIDÆ** Nickles and Bassler

Genus **INTRAPORA** Hall

Intrapora fragilis, n. sp. Plate 2, fig. 6

Zoarium bifoliate, of irregular expansions; surface wrinkled, without monticules. Apertures opening directly outward; elliptical in outline; average diameter 0.08 mm.; ten in space of 5 mm.; not regularly arranged; separated by distances of less than one to more than four apertures. Peristomes low and sharp. Mesopores abundant, angular, small; approximately half size of apertures. Acanthopores not observed.

Remarks.—*Intrapora fragilis* can be distinguished from other South and North American species by its very minute apertures.

Type.—Holotype: Pal. Res. Inst. No. 5889.

Intrapora megalopora, n. sp. Plate 2, fig. 7

Zoarium bifoliate; of irregular expansions, surface wrinkled; without monticules. Apertures opening directly outward, elliptical in outline; average diameter 0.25 mm.; eight in space of 5 mm.; not regularly arranged; separated by distances of less than one to more than six apertures. Peristomes low and sharp. Mesopores abundant, angular, not conspicuous; approximately one-third size of apertures. Acanthopores not observed.

Remarks.—*Intrapora megalopora* can be distinguished from *I. fragilis,* n. sp. by its much larger apertures, and from *I. puteolata* Hall of the Hamilton by its less prominent mesopores.

Type.—Holotype: Pal. Res. Inst. No. 5891.

Family **FENESTRELLINIDÆ** Bassler
Genus **FENESTRELLINA** d'Orbigny

Fenestrellina colombiana, n. sp. Plate 3, figs. 1, 2, 7

Zoarium a flabellate expansion.

Obverse.—Branches angular; average width 0.26 mm.; eleven in space of 5 mm. Dissepiments narrow, rounded; not depressed below plane of branches; seven or eight in space of 5 mm. Fenestrules oval, flattened laterally. Apertures small, circular; average diameter 0.08 mm.; opening directly outward, twenty-six in space of 5 mm., approximately three to a fenestrule; separated by distances slightly greater than diameter of apertures. Peristomes weakly developed, not indenting margins of fenestrules. Carina prominent, sharp; divided at point of bifurcation; new ranges of apertures appearing inside bifurcation.

Reverse.—Branches rounded, smooth, slightly thicker than those on obverse face. Dissepiments rounded, not depressed below plane of branches, considerably thicker than those on obverse face. Fenestrules elongate, flatter laterally than those on obverse face.

Remarks.—This species differs from *Fenestrellina harrisi,* n. sp. in not having inflected fenestrules, and in the larger size of fenestrules. It is very similar to a number of North American Middle Devonian species and differs from *F. eudora* (Hall) of the Helderberg and *F. parallela* (Hall) of the Hamilton only in the shape and proportion of the branches and dissepiments.

Types.—Holotype: Pal. Res. Inst. No. 5892; paratypes: 5893, 5894.

Fenestrellina olssoni, n. sp. Plate 3, figs. 4, 5, 6

Zoarium a flabellate expansion.

Obverse.—Branches broad, angular and subparallel; average width 0.3 mm.; widest immediately before bifurcation; six or seven in space of 5 mm. Dissepiments slender, rounded, depressed below plane of branches; five in space of 5 mm. Fenestrules elliptical, not inflected by apertures. Apertures circular; average diameter 0.12 mm.; often opening directly upward, sometimes opening laterally; seventeen to eighteen in space of 5 mm.; separated by distances greater than diameter of apertures. Peristomes low, inconspicuous. Carina high and thin, simulating those found in *Semicoscinium.*

Reverse.—Branches rounded; occupied at irregular intervals by sharp spines. Dissepiments slightly depressed below plane of branches. Fenestrules oval to circular, same size as those on obverse face.

Remarks.—*Fenestrellina olssoni* differs from other species of *Fenestrellina* found in the Colombian fauna by its larger sized branches and fenestrules and strong, high carinæ. It can be distinguished from *F. venezuelensis* (Weisbord) chiefly by its rounded reverse branches which bear sharp, low spines.

Types.—Holotype: Pal. Res. Inst. No. 5896; paratypes: 5897, 5898.

Fenestrellina acuta, n. sp. Plate 3, fig. 3

Zoarium a flabellate expansion.

Obverse.—Branches angular; average width 0.4 mm.; nine in space of 5 mm. Dissepiments broad, angular; slightly depressed below plane of branches; usually oblique to branch; five or six in space of 5 mm. Fenestrules elliptical, small compared to width of branches and dissepiments. Apertures small, circular; average diameter 0.12 mm.; opening directly outward; sixteen in space of 5 mm.; averaging three to a fenestrule; separated by distances equal to diameters of apertures. Peristomes weakly developed or absent, apertures usually opening flush with or slightly below surface of branch. Carina prominent, sharp, crenulated.

Reverse.—Not known.

Remarks.—This species differs from other species of *Fenestrellina* in having persistent oblique dissepiments.

Type.—Holotype: Pal. Res. Inst. No. 5895.

Fenestrellina quadrata, n. sp. Plate 3, figs. 8, 9

Zoarium a flabellate expansion.

Obverse.—Branches narrow, angular and subparallel; average width 0.3 mm.; widest immediately before bifurcation; six or seven in space of 5 mm. Dissepiments slender, rounded; slightly depressed below plane of branches; irregularly arranged; four to eight in space of 5 mm.; at irregular intervals two occur close together. Fenestrules of two sizes, the larger are elongate, rectangular in outline; the smaller oval or circular in outline; caused by irregular spacing of dissepiments. Apertures small, circular; average diameter 0.08 mm.; opening directly outward; twenty-four in space of 5 mm.; separated by distances approximately equal to diameters of apertures. Peristomes low, inconspicuous. Carina broad, rounded, bearing sharp, elongate spines separated by intervals of approximately 0.5 mm.

Reverse.—Branches rounded, smooth, without nodes. Dissepiments rounded, not depressed below plane of branches. Fenestrules similar to those on obverse face.

Remarks.—*Fenestrellina quadrata* is distinguished from other species of *Fenestrellina* by the occurrence of fenestrules of two sizes.

Types.—Holotype: Pal. Res. Inst. No. 5899; paratype: 5900.

Fenestrellina harrisi, n. sp. Plate 4, figs. 1, 2

Zoarium a flabellate expansion.

Obverse.—Branches narrow, angular and subparallel; average width 0.27 mm.; widest immediately before bifurcation; twelve in space of 5 mm. Dissepiments slender, rounded; slightly depressed below plane of branches; eight in space of 5 mm. Fenestrules elliptical, sometimes inflected by apertures; length 0.5 mm.; width 0.14 mm. Apertures small, circular; average diameter 0.08 mm.; opening laterally and directly upward; those nearest dissepiments sometimes larger than others; twenty in space of 5 mm.; separated by distances approximately equal to diameters of apertures; three, and occasionally four rows of apertures present on branch for a short distance before bifurcation. Peristomes prominent, often indenting margins of fenestrules. Carina not prominent, bearing regularly spaced low nodes.

Reverse.—Branches rounded, smooth, without nodes. Dissepiments rounded, not depressed below plane of branches. Fenestrules elongate, occasionally emarginated, slightly wider than those on obverse face.

Remarks.—On superficial examination *Fenestrellina harrisi* appears to be much like *F. colombiana* but the two species can be distinguished by the manner in which bifurcation of the branches takes place. *F. harrisi* is similar to *F. rockportensis* McNair from the Traverse of Michigan, but differs from it in being considerably smaller in size. *F. harrisi* belongs to the group of species of *Fenestrellina* which Simpson designated *Polyporella,* a name discarded by Nickles and Bassler as a synonym of *Polypora.* It is the writer's belief that *Polypora* could be used to designate all species of *Fenestrellina* which have more than two rows of apertures on the branch before places of bifurcation and which also have a rather well developed carina.

Types.—Holotype: Pal. Res. Inst. No. 5901; paratype: 5902.

Genus SEMICOSCINIUM Prout

Semicoscinium colombiensis, n. sp. Plate 4, figs. 3, 4, 5

Zoarium flabellate or funnel-shaped; celluliferous on concave side.

Obverse.—Branches thick, angular, subparallel, regularly sinuous; average width 0.5 mm.; seven to eight in space of 5 mm. Dissepiments broad, flattened, depressed below plane of branches; four in space of 5 mm.; adjacent branches closest together at dissepiments. Fenestrules elliptical; alternating in position on sides of branches; length 0.5 to 1.0 mm.; width 0.3 to 0.6 mm.; slightly smaller than on reverse face. Apertures small and circular; average diameter 0.12 mm.; opening laterally; seventeen to twenty-one in space of 5 mm.; separated by distances slightly greater than diameters of apertures. Peristomes thin, conspicuous. Carina prominent, high, thin, flexuous; usually broken near top of branch.

Reverse.—Branches angular, difficult to distinguish from dissepiments; marked by keel-like projections arranged parallel to long axis of branch. Dissepiments only slightly depressed below plane of branches; do not bear keel-like projections. Fenestrules oval; length 0.7 to 1.0 mm.; width approximately 0.5 mm.

Remarks.—One of the strange features of *Semicoscinium colombiensis* is that all the specimens available for study show that the apertures occur on the concave side of the zoaria. The opposite condition has been described in all other species of the genus. Subsequent study may prove that this species belongs to a new genus which simulates members of true *Semicoscinium* in all respects other than the method of budding of zoöids in early stages in zoarial growth. *S. colombiensis* is easily distinguished from *S.* (?) *minutum,* n. sp. by its much larger size and flexuous rather than straight branches.

Types.—Holotype: Pal. Res. Inst. No. 5904; paratypes: 5903, 5905.

Semiscoscinium (?) minutum, n. sp. Plate 4, fig. 6

Zoarium flabellate, not funnel-shaped, extending upward and outward from a spreading base.

Obverse.—Branches thin, angular, strongly spreading; average width 0.28 mm.; ten or twelve in space of 5 mm. Dissepiments thin, depressed below plane of branches, seven or eight in space of 5 mm. Fenestrules irregularly rectangular in outline; length 0.5 mm.; width 0.1 mm.; usually inflected by apertures. Apertures small and circular; average diameter 0.08 mm.; opening directly upward; approximately twenty-three in space of 5 mm.; separated by distances slightly greater than diameters of apertures. Peristomes conspicuous. Carinæ very strong, straight, expanded at summit to form strong rodlike ridges.

Reverse.—Not known.

Remarks.—This species is tentatively placed in the genus *Semicoscinium* because the method of zoarial grown is not typical. It can be distinguished from other species of *Semicoscinium* by its very small size and by its prominent, rounded carina. Further study might indicate that this species should be placed in *Fenestrellina.*

Type.—Holotype: Pal. Res. Inst. No. 5906.

Genus **UNITRYPA** Hall

Unitrypa casteri, n. sp. Plate 4, figs. 7, 8, 9

Zoarium flabellate or funnel-shaped.

Obverse.—Branches thick, angular, subparallel; average width 0.5 mm.; eight in space of 5 mm. Dissepiments broad, depressed below plane of branch; six in space of 5 mm. Fenestrules irregular, elongate, not inflected by apertures; length approximately 1.0 mm.; width 0.3 to 0.5 mm. Apertures large, circular; average diameter 0.09 mm.; opening laterally; nineteen in space of 5 mm.; separated by distance approximately equal to diameters of apertures. Peristomes inconspicuous. Carina expanded to form a reticulate superstructure. Superstructure prominent; consisting of longitudinal ridges and lateral connecting bars; openings between ridges and bars irregularly hexagonal in outline, wider than long; average length 0.3 mm.; average width 0.7 mm.

Reverse.—Branches rounded, slightly striated and nodose. Dissepiments rounded; depressed below plane of branches. Fenestrules elongate, length 1.0 mm.; average width 0.3 mm.

Remarks.—*Unitrypa casteri* is one of the most conspicuous elements in the Colombian fauna because of the large size of the zoaria and the conspicuous reticulate superstructure. This species is distinguished from North American species by its delicate superstructure. The longitudinal ridges and connecting bars are much thinner than those of any previously known species.

Types.—Holotype: Pal. Res. Inst. No. 5907; paratypes: 5908, 5909.

Genus **POLYPORA** McCoy

Polypora elegantula, n. sp. Plate 5, figs. 1, 2

Zoarium flabellate, growing from a flattened base.

Obverse.—Branches rounded; 0.3 to 0.7 mm. in width; widest immediately before bifurcation; straight, subparallel to strongly divergent; six to nine in space of 5 mm. Dissepiments slender, rounded, depressed below plane of branches; seven to nine in space of 5 mm. Fenestrules regularly elliptical; length 0.4 to 1.0 mm. Apertures circular; average diameter 0.08 mm.; two to four ranges occur on a branch; twenty-one in space of 5 mm.; separated by distances two or three times greater than diameter of apertures; arranged in longitudinal ranges separated by inconspicuous fine striæ. Peristomes low, not prominent.

Reverse.—Not known.

Remarks.—*Polypora elegantula* can be distinguished from *P. granulifera,* n. sp. by its much smaller sized branches and fenestrules and relatively larger sized apertures. It has larger fenestrules than *P. obliqua* (Hall) of the Helderberg.

Types.—Holotype: Pal. Res. Inst. No. 5910; paratype: 5911.

Polypora granulifera, n. sp. Plate 5, figs. 3, 4, 5, 6, 7, 8

Zoarium funnel-shaped; celluliferous on inner side.

Obverse.—Branches rounded, broad; widest immediately before bifurcation; 0.3 to 1.3 mm. in width; straight or sinuous, subparallel. Dissepiments short, thick; slightly depressed below plane of branches; width 0.6 mm.; three or four in space of 5 mm. Fenestrules elliptical; average length 1.2 mm.; average width 0.6 mm.; those on one side of branch alternate in position with those on other side. Apertures in three to seven ranges; average diameter 0.07 mm.; seventeen in space of 5 mm.; separated by distances greater than diameters of apertures; arranged in regular longitudinal ranges separated by low, straight or sinuous striations. Peristomes low, thick.

Reverse.—Branches angular, sinuous, usually striated. Dissepiments strong, angular, not depressed below plane of branches. Fenestrules elliptical, same size as those on obverse face.

Remarks.—*Polypora granulifera* is the most abundant species in the Colombian fauna. The large flexuous zoaria often cover considerable areas. The species differs from *Polypora cachirita* Weisbord in having larger fenestrules and by the absence of carina on the branches.

Types.—Holotype: Pal. Res. Inst. No. 5912; paratypes: 5913, 5914, 5915, 5916, 5917.

Family SULCORETEPORIDÆ Bassler

Genus SULCORETEPORA d'Orbigny

Sulcoretepora subramosa, n. sp. Plate 6, fig. 1

Zoarium with dichotomizing branches; distance between bifurcations 7 to 10 mm.; branches curved or straight; width approximately 4.0 mm. Apertures opening directly outward; circular in outline; those near margins slightly larger than those in central part of branch; average diameter 0.10 mm.; twelve in space of 5 mm.; separated longitudinally by distances greater than diameter of apertures. Peristomes conspicuous. Lunaria absent. Eight to twelve ranges on a branch. Ridges between ranges low, sometimes striated. Margin nonporiferous, edge rounded; broad between bifurcations.

Remarks.—*Sulcoretepora subramosa* is much like *S. incisurata* (Hall) from the Hamilton group of North America. It differs from it in having less prominent longitudinal ridges and by its much smaller apertures. The method of growth of the zoarium in the species varies considerably, varying from narrow, straight stipes with distant branches to curved broad stipes with rather frequent branches.

Type.—Holotype: Pal. Res. Inst. No. 5918.

Sulcoretepora olssoni, n. sp. Plate 6, fig. 2

Zoarium with alternately arranged branches; distance between bifurcations of new branches approximately 5 mm. Branches curved and flat; width 2 to 4 mm. Apertures opening directly outward; subcircular to elliptical in outline; average diameter 0.2 mm.; seven to nine in space of 5 mm.; most of them separated longitudinally by distances less than length of apertures, being closest at points of origin of new ranges and separated transversely by distances less than width of apertures. Peristomes weak and thin. Lunaria not observed, apparently not developed. New ranges arise by alternate offsetting of apertures. Most new ranges continue into secondary branches. Five to nine ranges occur on a branch. Ridges between ranges straight, prominent and angular; new ridges originate between new ranges. Margins nonporiferous; width moderate, edge rounded.

Remarks.—This species is very similar to *Sulcoretepora alternata* McNair from the Traverse group of Michigan, differing from it however, in having sharper longitudinal ridges, weaker peristomes and in the apparent absence of lunaria.

Type.—Holotype: Pal. Res. Inst. No. 5919.

Genus **PRISMOPORA** Hall

Prismopora inornata, n. sp. Plate 6, fig. 3

Zoarium consisting of triangular branches; distance between branches greater than 15 mm. Faces concave; width varying from 2.0 to 5.0 mm. Apertures opening directly outward; subcircular in outline; average diameter 0.16 mm.; largest near margins; four to eight irregularly spaced apertures occur transversely across the face of a branch; usually separated by distances greater than diameter of apertures. Peristomes weak. Spaces between apertures flat, not ornamented. Margin nonporiferous, widest immediately above bifurcation of branches.

Remarks.—This species can be distinguished from others of the genus *Prismopora* by the irregular arrangement of apertures.

Type.—Holotype: Pal. Res. Inst. No. 5920.

Genus **TÆNIOPORA** Nicholson

Tæniopora florestæ, n. sp. Plate 6, fig. 4

Zoarium consisting of triangular branches; distance between branches of some specimens at least 2.0 mm. Faces of branch concave, subequal in width; usually two faces considerably narrower than the other; width from 2 to 4 mm. Apertures opening direct or oblique to faces, circular in outline; average diameter 0.15 mm.; arranged in longitudinal and transverse ranges; largest near margins of faces; separated longitudinally by distances greater than diameters of apertures; separated transversely by distances less than diameters of apertures. Peristomes low. Margin angular, nonporiferous.

Remarks.—This species is one of the less common members of the fauna. It resembles *T. exigua* Nicholson of the North American Hamilton formations, differing from it in its much larger apertures. The genus *Tæniopora* has been discovered only in Middle Devonian rocks of North America where only five species have been described and the presence of a species of this genus in th Colombian fauna is one of the indications of the relationship of the Colombian fauna.

Type.—Holotype: Pal. Res. Inst. No. 5921.

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EXPLANATION OF PLATES

PLATE 1 (XI)

All specimens illustrated on this and the succeeding plates are from the Devonian strata of Floresta, Department of Boyaca, northeastern Colombia, South America.*

EXPLANATION OF PLATE 1 (11)

Figure Page

1. **Cyclotrypa stellata, n. sp.** 8
   Surface of zoarium showing arrangement of apertures, maculæ and spines. Holotype. Pal. Res. Inst. No. 5879.
2. **Cyclotrypa boyaca,** n. sp. 8
   Surface of zoarium showing regular arrangement of apertures, a macula and the low, distant spaced spines in the interapertural spaces. Holotype. Pal. Res. Inst. No. 5880.
3. **Cyclotrypa boyaca,** n. sp. 8
   Surface of zoarium showing smaller, more distant spaced apertures than those of holotype. Paratype. Pal. Res. Inst. No. 5881.
4. **Cyclotrypa carribeana,** n. sp. 9
   Surface of zoarium showing smooth maculæ and interapertural spaces and the enlarged apertures surrounding the macula. Paratype. Pal. Res. Inst. No. 5883.
5. **Cyslotrypa stellata,** n. sp. 8
   Paratype, showing elongate maculæ, spines poorly shown. Pal. Res. Inst. No. 5882.
6. **Cyclotrypa carribeana,** n. sp. 9
   Surface of zoarium showing arrangement of apertures and maculæ. Holotype. Pal. Res. Inst. No. 5884.

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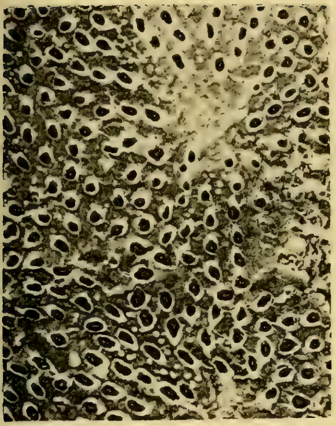
*All figures on this and the succeeding plates are magnified 7½ times and are photographs of impressions. A description of the method used in making the photographs is given on page 7.



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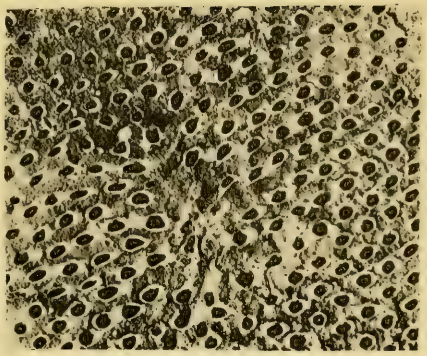

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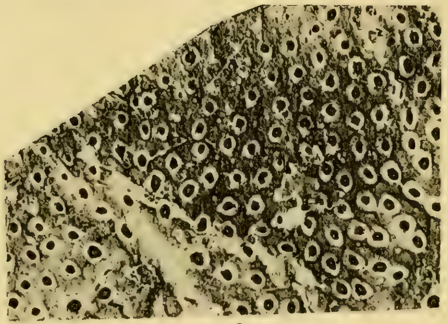

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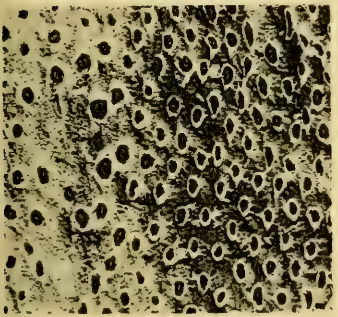

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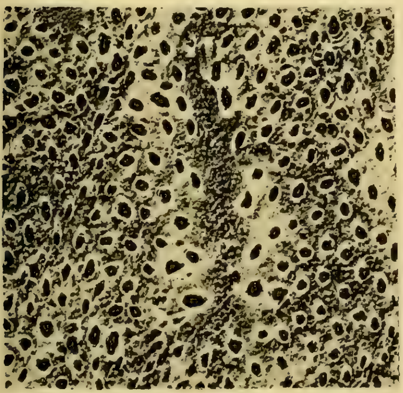

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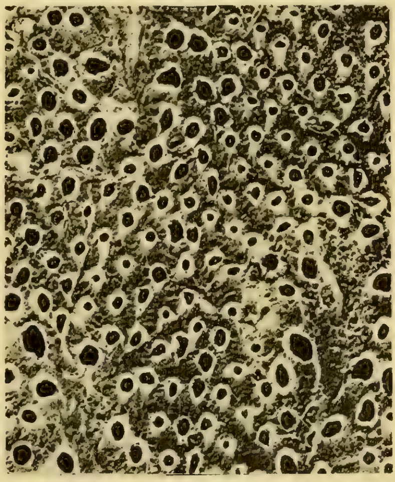

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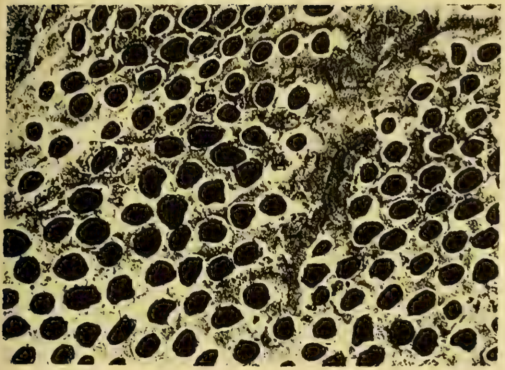
PLATE II (XII)

EXPLANATION OF PLATE 2 (12)

Figure		Page
1.	**Fistulipora megalopora, n. sp.** Surface of zoarium showing large circular apertures and elongate maculæ. Lunaria not shown. Holotype. Pal. Res. Inst. No. 5885.	10
2.	**Cyclotrypa dickeyi, n. sp.** Surface of zoarium showing stellate maculæ and relatively large far spaced apertures. Holotype. Pal. Res. Inst. No. 5886.	9
3.	**Fistulipora (?) anomala, n. sp.** Surface of zoarium showing distribution of maculæ and apertures and lunaria within apertures. Note absence of peristomes. Maculæ are much more depressed than the figure indicates. Holotype. Pal. Res. Inst. No. 5887.	11
4.	**Fistulipora (?) delicata, n. sp.** Surface of zoarium showing circular maculæ, small oblique apertures, prominent lunaria and small interapertural spines. Holotype. Pal. Res. Inst. No. 5888.	11
5.	**Cyclotrypa (?) reticulata, n. sp.** Surface of zoarium showing small, far-spaced apertures and straight walled vesicles in the interapertural spaces. Holotype. Pal. Res. Inst. No. 5889.	10
6.	**Intrapora fragilis, n. sp.** Surface of zoarium showing small crowded apertures and indistinct mesopores. Holotype. Pal. Res. Inst. No. 5890.	11
7.	**Intrapora megalopora, n. sp.** Surface of eroded specimen showing elliptical apertures and mesopores. Holotype. Pal. Res. Inst. No. 5891.	12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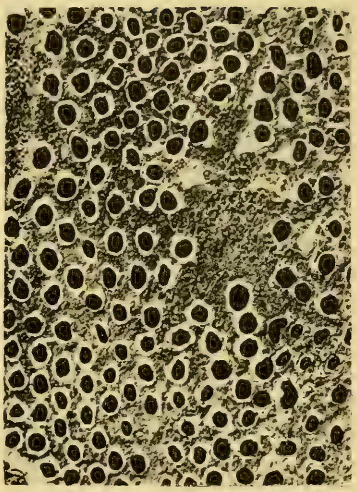
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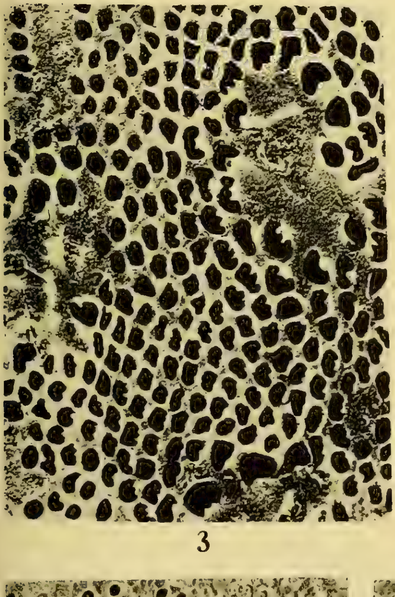
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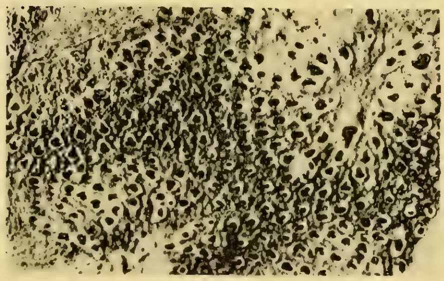
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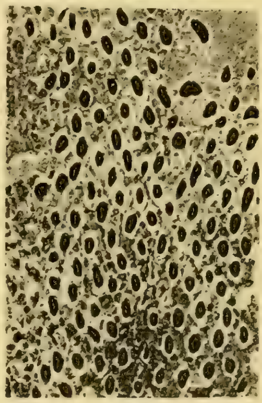
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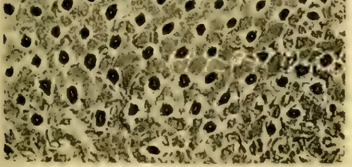
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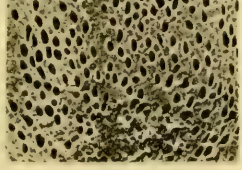
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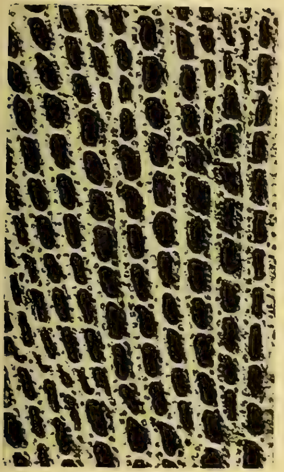
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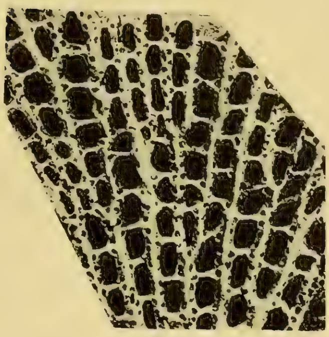
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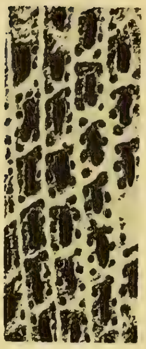
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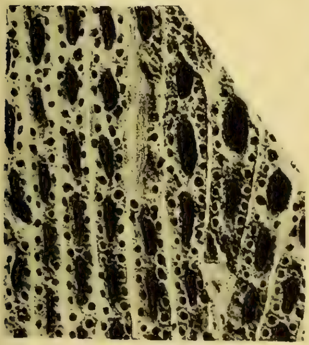
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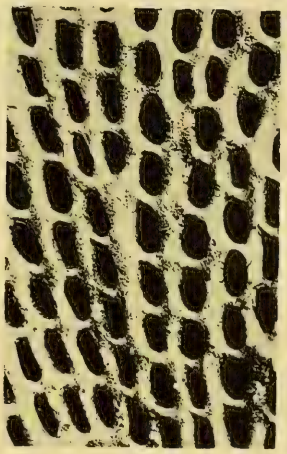
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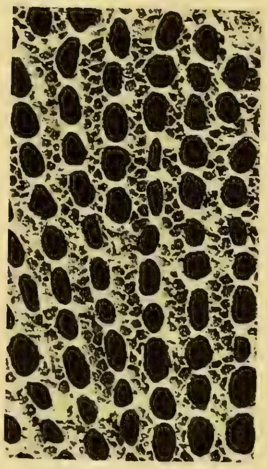
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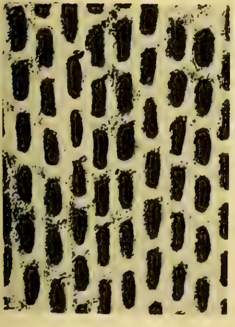
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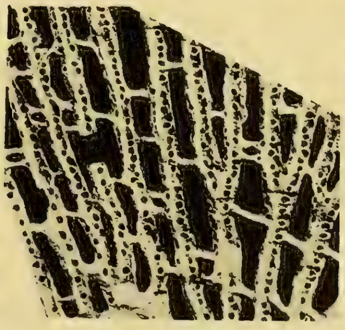
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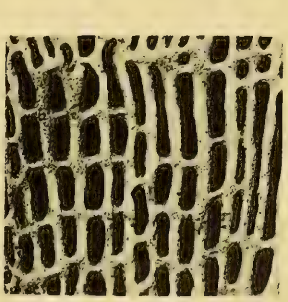
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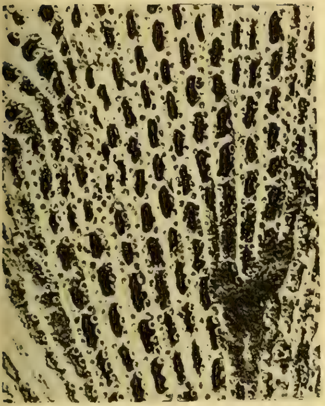
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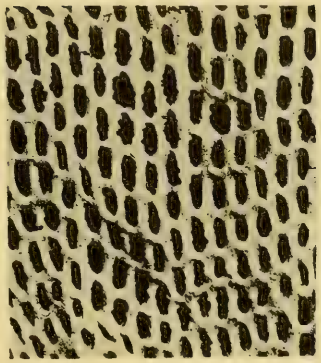
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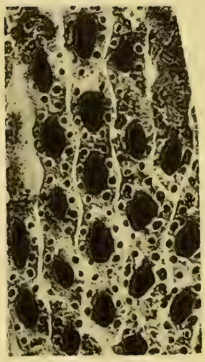
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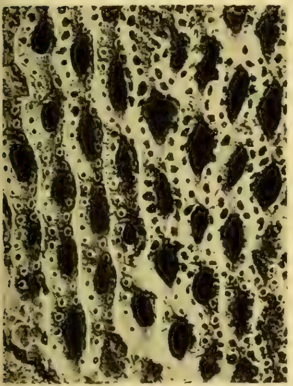
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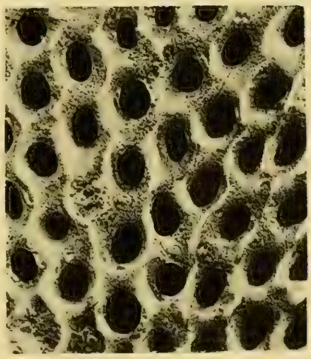
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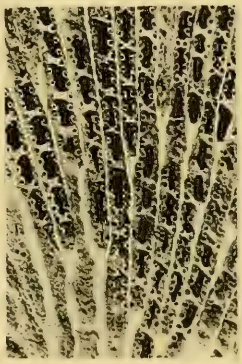
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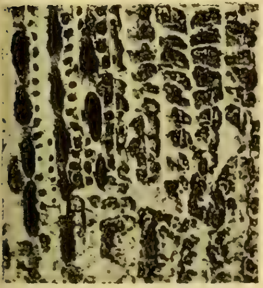
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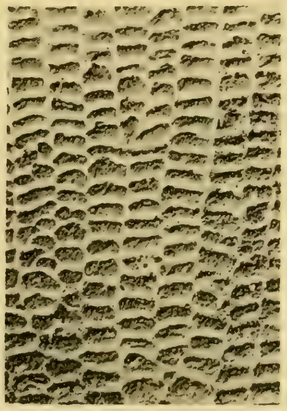
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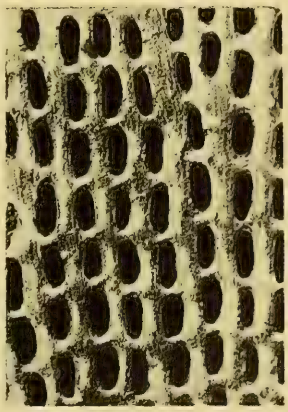
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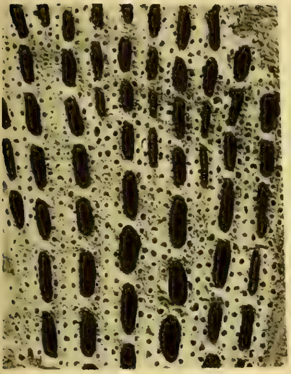
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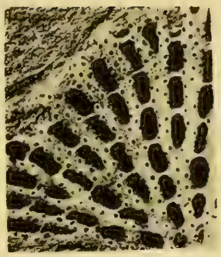
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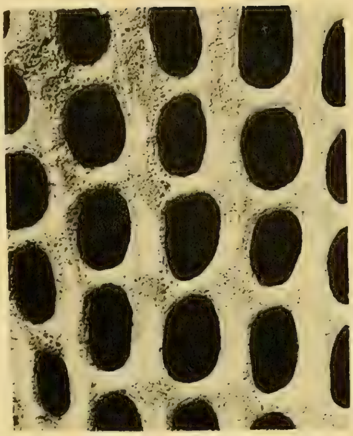
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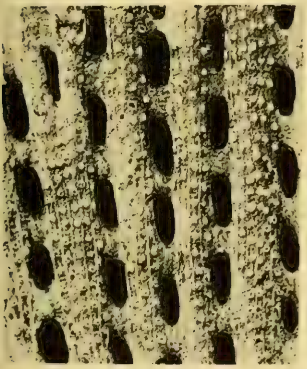
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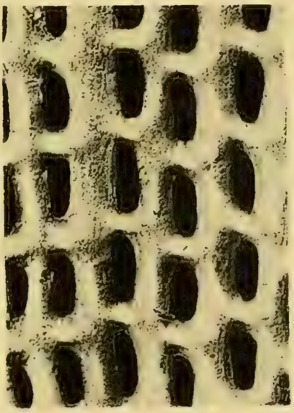
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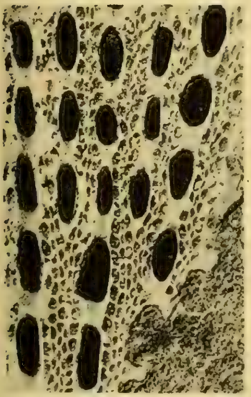
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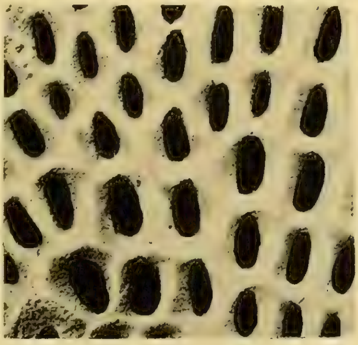
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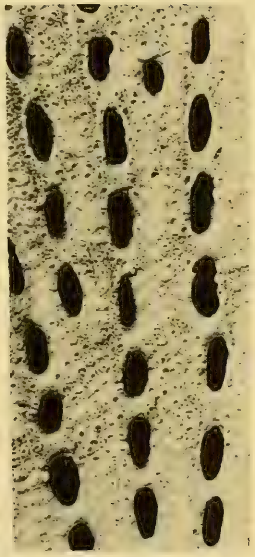
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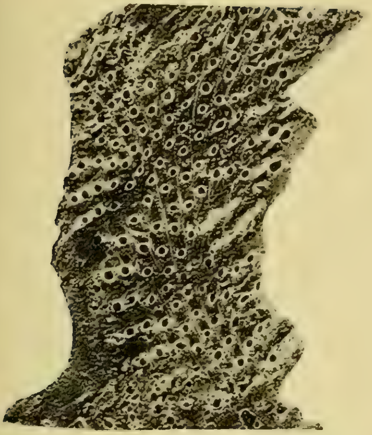

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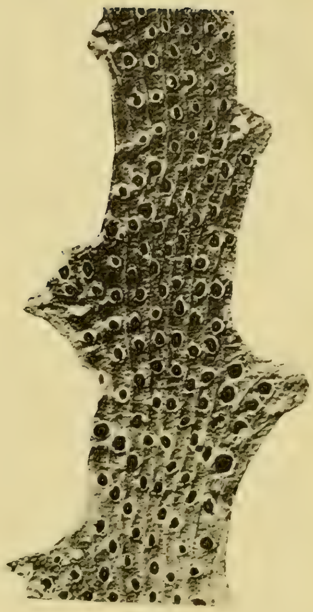

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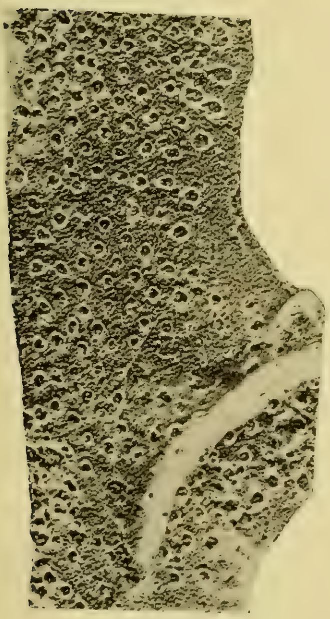

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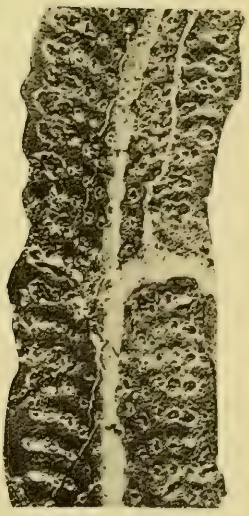

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VOL. XXV

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Ithaca, New York

U. S. A.

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Vol. 25

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No. 94 A

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New Mollusca from the Pleistocene of San Pedro, California – I

By
S. Stillman Berry

September 28, 1940

Paleontological Research Institution
Ithaca, New York
U. S. A.

NEW MOLLUSCA FROM THE PLEISTOCENE OF SAN PEDRO, CALIFORNIA—I

By
S. Stillman Berry
Redlands, California

In the course of work now in progress on several exposures of the Pleistocene, some of them not long opened, in the San Pedro area, the shells of a number of mollusks have appeared in the collections which I have been unable to identify with any previously described species. In order that specimens may be distributed to other students, diagnoses of seven of these are offered herewith. The field is so vast and the literature now so large and so exceedingly scattered that there is always the chance that some stray description has been overlooked. Nevertheless I hope that the present contribution to it will not result in further needless encumbrance of the synonymy. Some, if not all of these species will doubtless be found to be still living, as the waters not only of the near vicinity but particularly of western Lower California are more fully explored.

Crassinella nuculiformis, new species Plate 1, figs. 1, 2

Diagnosis.—Shell small, wedge-shaped, nearly equivalve, strongly inequilateral, moderately convex, moderately thick and heavy; umbonic angle abrupt, a little more than rectangular; anterior dorsal margin nearly straight, anterior angle obtusely rounded, posterior dorsal margin slightly arcuate into the rounded posterior extremity; ventral margin more evenly arcuate. Umbones sculptured externally by low wavelike concentric ridges, which in a few specimens persist over the shell and are nearly lamellose, but more often pass gradually into the rather irregular and variable growth lines of the adult shell. Beaks, when uneroded, distinctly arcuate over the long narrowly heart-shaped lunule, which is separated by a distinct carina from the remaining portion of the shell; a pair of straighter carinations circumscribes a smaller and narrower depressed area on the posterior slope of the shell.

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Interior smooth, with well-defined muscle scars; pallial line entire; extreme shell margin rather sharp and thin, a low ridge just inside it often giving it a more or less duplex appearance. Cardinal teeth large, heavy, the major tooth in the left valve conspicuously prominent; both teeth in right valve massive, strongly elevated, and often more or less overhanging posteriorly.

Measurements.—Max. long. of largest paratype, 6.8, anterior height (at base of "wedge"), 5.5, thickness, 1.7 mm.; max. long. of holotype, 5.3, anterior height, 4.4, thickness, 1.3 mm.

Holotype.—A right valve, Cat. No. 7707, Berry Collection.

Paratypes.—Cat. No. 7708, Berry Collection; others to be deposited in the collections of Stanford University, Pomona College, the San Diego Museum, and the United States National Museum.

Type locality.—West side of Gaffey Street in cut just below General Street, San Pedro, California; S. S. Berry and R. K. Cross.

Remarks.—This is a solid, compact little species, readily separable from its associated congener, *C. branneri* Arnold, by its smaller size, more obsolescent sculpturing, more arcuate and less sharply pointed beaks, and decidedly wedge-shaped rather than triangular contour. The recently described *goldbaumi* Jordan (:36, p. 126, pl. 18, f. 4, 5) is likewise much more trigonal in outline. Many of the pairs occur intact and in this condition simulate another associated but quite unrelated species, *Nucula exigua* Sowerby (=*suprastriata* Carpenter), except that they are not so plump. It is from this circumstance that the specific name selected derives its appropriateness. Both species of *Crassinella* together with the *Nucula* occur similarly associated and very abundantly in the Pleistocene of Spanish Bight, San Diego, as evidenced by material from that exposure sent me by Mrs. Kate Stephens.

Although not noted by Arnold, many specimens of *C. branneri* show a very minute, close and delicate radial striation covering the outer surface of the valves, no trace of which I have been able to detect on the present species.

I find the descriptions of the hinge of *Crassinella* in the literature available to me exceedingly contradictory and confusing, and the homologies are not at all clear without a more prolonged study and considerably more extensive comparative material than I have been able to bring to bear upon them.

Tivela scarificata, new species Plate 1, fig. 5

Diagnosis.—Shell (if those seen be near maturity) rather small for the genus, heavy, elongate-trigonal in outline, slightly inequilateral, beaks strongly inturned; postero-dorsal margin weakly sinuous, slightly concave above; the anterior dorsal margin nearly straight; posterior margin a little produced, more narrowly rounded than the anterior, the region above it somewhat flattened and separated from the rest of the shell by a low but fairly distinct carina. Outer surface smooth except for the numerous lines of growth and a few concentric grooves, especially evident anteriorly, perhaps marking resting stages.

Middle cardinal in right valve strong, high, and long, forward slanting and slightly arcuate; posterior cardinal more strongly oblique, straighter, heavier, longer, but much lower, the pocket between them narrow; anterior cardinal thin, backward slanting, much the smallest and weakest of the three, the depression between it and the middle cardinal triangular, short, and rather wide Posterior cardinal in left valve the highest and longest, distinctly angular.

Pallial sinus large, rude; region inside pallial line heavily filled in, thickened, and calloused, with a rude, shallow, median radial groove flanked by traces of similar anterior and posterior grooves extending down from the umbo; region outside pallial line more or less heavily scarred and indented, the scars causing irregular puckerings and indentations in the pallial line itself.

Measurements of holotype.—Long., 44.6, height, 29.5, width, 8.3 mm.

Holotype.—A perfect right valve, Cat. No. 7709, Berry Collection.

Paratypes.—Cat. No. 7710, Berry Collection; others to be deposited in the collections of Stanford University, Pomona College, and the United States National Museum.

Type locality.—N. W. corner Beacon and Second Streets, San Pedro, California; S. S. Berry and R. K. Cross, 1934-5.

Remarks.—It seems incredible to find a new lamellibranch as conspicuous as this *Tivela* in a deposit as long known and well worked as the Lower San Pedro, but I cannot discover any species in the literature with which it seems possible to identify it. It is longer and narrower than *stultorum* (Mawe), has a more sinuous posterior slope, and the thickened and scarified interior is exceedingly peculiar, not only in *Tivela*, but among all our Veneridæ so far as I am aware. The specific term proposed is derived from the Latin, *scarifico,* to scarify.

Clavus (Crassispira) zizyphus, new species **Plate 2, fig. 1**

Diagnosis.—Shell of moderate size, thick and heavy; spire moderately high, its slopes somewhat arcuate in outline; whorls nine (+the lost apex), only slightly inflated, sculptured with low, obliquely slanting axial ribs extending down from the anal fasciole nearly to the suture, except on the body whorl where they are about 21 in number, but are weaker and shorter, often becoming obsolete below the periphery as they near the aperture; entire surface of shell spirally ridged, the ridges evident to the naked eye in excess of 20 on the body whorl, not including a number of minor riblets intercalated between the major spirals in the anterior region; growth lines fairly distinct, the major ones usually coinciding in position with the ribs; aperture somewhat less than half the length of the shell, heavily calloused above the deep, round anal notch, which is well below the suture, very neatly turned, and has its entrance slightly constricted from the posterior side; inner lip also well calloused; columella gently arcuate, its curve leading into that of the short, weakly recurved canal; outer lip at first slightly arcuate, then constricted inward a little where it passes into the canal; body whorl to left of aperture rapidly and arcuately sloping inward to the canal.

Color of periostracum a warm light-brown (near Orange-Cinnamon of Ridgway) very well preserved in the fossils, paler on the spire, the axial ridges shaded a little deeper (Verona-Brown), a narrow somewhat deeper toned spiral band above and a rather wider one below on the body whorl; periostracum with a satiny sheen.

Measurements of holotype.—Alt., 23.5, maj. diam., 8.3, length aperture, 10.6 mm.

Holotype.—Cat. No 7703, Berry Collection.

Paratypes.—Cat. No. 7704, Berry Collection; others to be deposited in the collections of Stanford University, Pomona College, and the United States National Museum. USNM 522571.

Type locality.—Lower Pleistocene—"Hilltop Quarry," San Pedro, California; S. S. Berry, R. K. Cross, and E. P. Chace.

Remarks.—This is a solid and compact, yet beautiful species, apparently somewhat of the general type of *C. rugitectus* (Dall, :19, p. 26, pl. 7, fig. 6), more finely and delicately sculptured and materially smaller than that species, yet with a heavier posterior apertural callus and a deeper anal sulcus. Furthermore the spiral cords show clearly across the ribs.

Possibly still closer is the recently described *kluthi* Jordan (:36, p. 153, pl. 18, fig. 1), but sufficient differences appear to lie in the ribby rather than nodulous axial sculpture, more numerous ribs, stronger spiral threading, and rather more attenuate spire.

The specific name proposed was suggested by the resemblance borne by the shell in size and outline to a seed of the common jujube (*Zizyphus*).

The preservation of the periostracum, which extends even to the coloring on most of the specimens, gives the shells a fresh, recent look shared by very few of the accompanying species.

VERTICUMBO, new genus

Shell subcrepiduloid, but with an expansive, clearly spiral, excentric, dextral shell, and a strongly excentric concave deck within.

Type.—*V. charybdis,* n. sp.

The name is derived from the Latin, *verto,* to turn, + *umbo,* boss of a shield, and has reference to the appearance of the nepionic shell in the adult.

Verticumbo charybdis, new species Plate 1, figs. 6-10

Diagnosis.—Shell subcrepiduloid or haliotoid, rather thin, chalky, fragile, almost circular, moderately elevated; nucleus of about 1½ whorls, strongly spirally mammillate, excentric, posterior, the shell thence expanding rapidly to maturity; highest at nucleus or just in front of it; exterior surface either unsculptured except for numerous growth lines of varying strength, or exhibiting a varying number (up to 15 or 16) of coarse, irregularly sinuous, radial (*i.e.* spiral) ridges, running in general perpendicular to the tangent of the growth lines. Interior white to light-buff, polished, the short wide deck convex, strongly excentric, and covering perhaps a quarter of the main cavity.

Measurements (*in mm.*).—

	Long.	Lat.	Alt.
No. 9456 holotype	8.7	9.2	3.6
No. 8611 Timm's Point	16.4	16.7	5.6
No. 8611a Timm's Point	16.1	15.1	5.5

Holotype.—Cat. No. 9456, Berry Collection.

Paratypes.—Cat. No. 8147, Berry Collection; others to be deposited in the collections of Stanford University and the United States National Museum.

Type locality.—Lower Pleistocene, bluff in alley south of Second Street and east of Pacific Street, San Pedro, California; 4 shells, S. S. Berry, 13 Oct., 1935.

Additional material.—Lower Pleistocene (Timm's Point formation), Timm's Point, San Pedro, California; 9 shells, Tom Burch, 1937.

Remarks.—Although I have had this fossil in hand as a novelty for a number of years, I have delayed the publication of the description prepared because I could not understand how a shell so remarkable, so conspicuous, and so interesting as this one is could have escaped the attention of previous students as study of the literature indicates that this was done. It appears in none of the relevant faunal lists unless perchance it is the same as the shell which certain authors have cited as *Crepidula aculeata,* which, though slightly similar superficially, is a very different thing and does not appear at all in any of my own collections from these horizons. I also feared that in describing a new genus for its reception, I might be adding a useless synonym to the nomenclature, but as to this I can only say that the most exhaustive search of all the collections and literature available to me has failed to reveal any described group to which this can properly be referred. *Crucibulum, Calyptræa,* and *Crepidula* all exhibit certain points of similarity, but the persistence to maturity of an indisputable spiral shell, as well as the corresponding structure of the deck and interior cavity, separates it in turn from each of these. To which of the genera mentioned it is most closely allied is thus not clearly apparent, and perhaps will not be unless and until its presence is revealed in the Recent fauna and an investigation can be made of its anatomy. That it should so come to light would surprise me not at all, although to date I have not seen the species even as a fossil in any later formations than those indicated.

Considerable variation is evident in the shells in hand, all my larger shells from Timm's Point being smooth, but I feel that the sculptural differences noted are more likely to prove those of *situs* than of race or even of the stage of maturity, although the latter consideration is of course not out of the question. The holotype is doubtless immature, but was selected because of its clear showing of some of the more trenchant characters.

The specific name has been selected because of the whirlpool-like formation of the shell when viewed within.

Acmæa lepisma, new species Plate 1, figs. 3, 4

Diagnosis.—Shell small, elongate-oval or oval-rectangular, thin, excessively fragile; ends obtusely rounded, sides weakly convex or nearly straight; moderately elevated, the apex strongly anterior in position, almost attaining the front margin; slope in front of apex distinctly concave but becoming weakly convex near the margin; posterior slope strongly arcuate, the declivity gentle at first, more rapid on the final two-fifths of the shell; apex minute, projecting, mammillate, a little lower than the slope just behind it, the slope in front and below it falling away at first almost perpendicularly into the concavity previously mentioned; lateral slopes convex. Upper surface marked by close, fine, conspicuous concentric growth lines, and a few crudely modeled and partially obsolete, narrow radiating ridges on the posterior slope, much more in evidence on some specimens than others.

Measurements.—(micrometer) of holotype.—Long., 5.14, lat., 2,96, alt., 1.65 mm; paratype.—Long., 4.64, lat., 2.5, alt., 1.11 mm.

Holotype.—Cat. No. 8609, Berry Collection.

Paratypes.—Cat. No. 8610, Berry Collection; others to be deposited in the collections of Stanford University, Pomona College, the San Diego Museum, the United States National Museum, and the private collection of E. P. Chace.

Type locality.—Lower Pleistocene—"Hilltop Quarry" (upper sandy beds), San Pedro, California; S. S. Berry, E. P. Chace, and Tom Burch.

Remarks.—This minute limpet is one of the characteristic species of Hilltop Quarry, but so delicate and fragile are the little shells that it is extremely difficult to recover them in perfect condition. The narrower specimens superficially suggest a possible affinity with the group of *A. paleacea* Gould, an abundant living species occurring rarely in the beds of the Quarry; otherwise one might question the species truly being an *Acmæa.* It is much wider and relatively flatter than *paleacea,* with a much more anterior apex and distinct traces of radial sculpture on the better preserved examples.

The specific name chosen comes from the Greek, *lepisma,* something peeled or scaled off.

Astræa (Pomaulax) petrothauma, new species Plate 2, figs. 2, 3

Diagnosis.—Shell large, conic, whorls more than 5; periphery with two powerful, heavily nodose carinæ, each carrying about 14 spirally aligned nodes to the whorl; intercarinal space concave; a third row of large well-separated comma-shaped, axially aligned nodules on the shoulder to the same number (especially heavy relative to the lower series on the earlier whorls) is without a carina; basal carina adnately presutural on spire; base flattened, but swollen toward the strongly arcuate columella, bearing one low major spiral riblet (sometimes barely nodulose in the young), another slightly weaker riblet near the columella, and from 1 to 2 still weaker ridges intercalated, besides sometimes a similar one just inside the inner major spiral; sutures impressed; aperture ovate-triangular, ample, pearly within; outer lip simple, except where crenated by the two carinæ; inner lip well calloused.

Operculum heavy, ovate, with a subterminal spiral nucleus; outer surface with posterior marginal ridge reduced to little more than a narrowly upturned rim; next succeeding ridge long, narrow, arcuate, coarsely granulose centrally; median ridge heavy, its initial granulation nearly or quite obsolescent with maturity, strongly arcuate and overhanging, the cavity between this and the short, smooth, S-shaped lowest ridge almost auriform.

Measurements of holotype.—Alt., 39.3, diam. body whorl, 49.3, height body whorl, 22.0, length aperture, 26.0 mm. Measurements of largest perfect operculum: long. (long diameter), 63.6, short diameter, 49.2, max. thickness, 17.5 mm.

Holotype.—Cat. No. 7701, Berry Collection.

Paratypes.—Cat. No. 7702, Berry Collection; others to be deposited in the collections of Stanford University and the United States National Museum.

Type locality.—Lower Pleistocene—"Hilltop Quarry," San Pedro, California; S. S. Berry and R. K. Cross.

Remarks.—This magnificent species is very near to the Pliocene *A.* (*P.*) *gradata* Grant & Gale (:31, p. 818), and may well be descended from it. It differs in the distinctly nodose basal keel, the less tabulate whorls, and particularly in the highly distinctive pattern of the opercular ridges. In most or all of these features it occupies a position in some degree midway between *gradata* and *undosa* (Wood). The Recent *turbanica* Dall is less conic in outline and apparently recognizably different in sculptural detail (cf. Grant & Gale, :31, pl. 31, fig. 2), but it clearly belongs to the same group. That all the shells seen by me are merely apices or juvenals is proven by the enormous operculum here figured (pl. 2, fig. 3) which measures 49.2 x 63.6 mm. This indicates that at full maturity this is a species far exceeding the living *undosa* in bulk, and complete specimens supporting this conclusion will doubtless some day be found.

The specific name proposed is derived from the Greek, *petra*, rock (whence the locality name, as well, has its original derivation), + *thauma*, marvel.

Calliostoma grantianum, new species Plate 2, figs. 4, 5

Diagnosis.—Shell of moderate size, trochiform, turreted, imperforate, moderately thick and heavy; whorls over 6½ (extreme apex of holotype wanting), narrowly shouldered, convex on the sides, carinate at the base, the carina emphasized by a sharp spiral cord with a second peripheral cord a little way above the first and nearly as heavy, the shoulder marked by a third somewhat weaker spiral; intercalary threads absent except a single one on the spire just below the suture and another which develops on the body whorl about midway of the shoulder and upper peripheral cords; base flattened or perhaps better described as weakly convex, nearly smooth, the spiral cords, which are but slightly raised to subobsolete, including a comparatively heavy median cord, a slightly weaker one between this and the basal angle, an intercalary spiral just outside the latter, and five progressively weaker spirals in the umbilical region; all spirals simple, entire, without beading; suture distinct, threaded by the not quite covered basal keel. Aperture squarish, oblique, the outer lip strongly angled into the basal keel; pillar heavy, short, oblique, apparently with a small thickened projection distally, but the lip somewhat damaged at this point in the holotype.

Measurements of holotype.—Maj. diam., 16.4, min. diam., 14.7, alt., 15.4, max. diam. aperture, 7.9, height aperture, 6.2 mm.

Holotype.—Cat. No. 8574, Berry Collection.

Type locality.—"Hilltop Quarry," San Pedro, California; E. P. Chace.

Remarks.—This is a trim and attractive shell, somewhat suggesting the living *costatum* of Martyn and the larger *canaliculatum nebulosum* Dall, with the latter of which it occurs in association in the type horizon. From *costatum* it is readily distinguishable by the sharper, heavier, and less numerous spiral cords and the double peripheral carination. From all forms of *canaliculatum* our species differs in the heavier shell, turreted spire, more convex whorls, coarser and sparser spiral cording, and the more irregular and obsolete basal threading. In the turreting, double peripheral carination, and general form, an approach is manifest to the Recent *turbinum* Dall, but the similarities are hardly fundamental enough to render necessary detailed comparison beyond the points already noted. Possibly still closer is Dall's *cammani* from the Miocene of Coos Bay,* but this seems a much more depressed shell, has no intercalated spirals above, and fewer and differently arranged basal threads.

The species is named in well-deserved honor of Dr. U. S. Grant, IV.

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* From the published figures it is a temptation to bring likewise into the comparison the Pliocene "**Chlorostoma**" **lahondaënsis** Arnold, 1908, and the Miocene "**Tegula**" **stantoni** Dall, 1909.

PLATES

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Note: I am especially indebted to Mr. George C. Varley of the University of Cambridge for his friendly and timely helpfulness in preparing four of the drawings.

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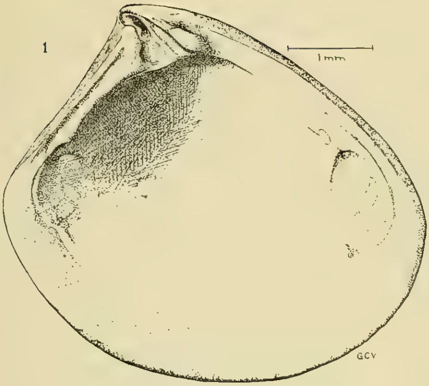

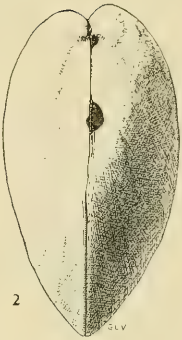

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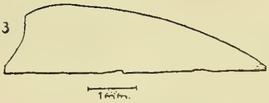

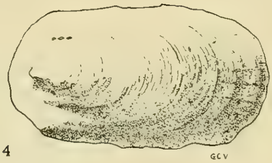

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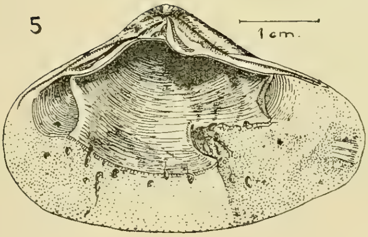

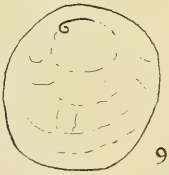

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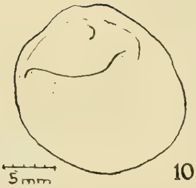

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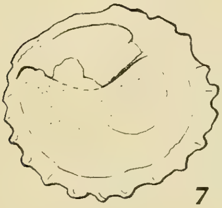

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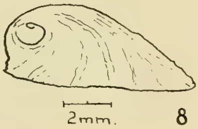

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PLATE 2 (18)

EXPLANATION OF PLATE 2 (18)*

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Holotype; Pleistocene of Hilltop Quarry, San Pedro, California; × 3.3.

2. **Astræa (Pomaulax) petrothauma,** n. sp. 10
Holotype; Pleistocene of Hilltop Quarry, San Pedro, California; × 1.1.

3. **Astræa (Pomaulax) petrothauma,** n. sp. 10
Outer aspect of operculum (paratype); Pleistocene of Hilltop Quarry, San Pedro, California; approximately natural size.

4-5. **Calliostoma grantianum,** n. sp. 12
Holotype; Pleistocene of Hilltop Quarry, San Pedro, California; × 2.2.

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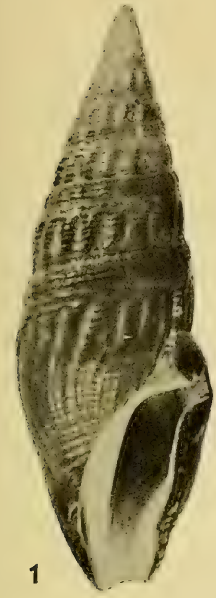
* All figures from photographs by Willam C. Vestal.



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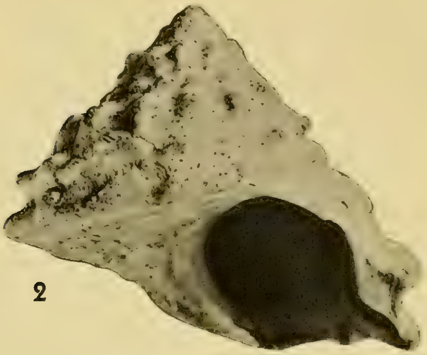

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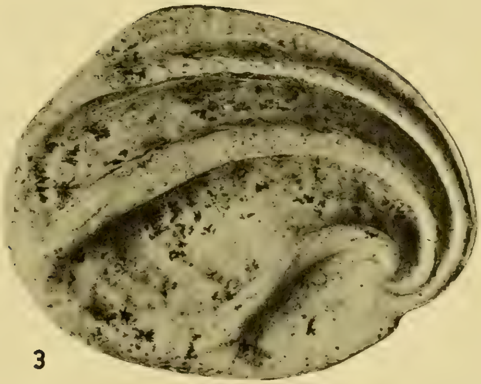

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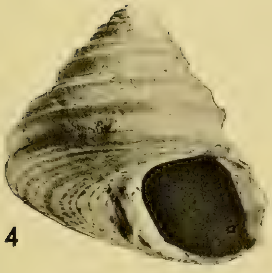

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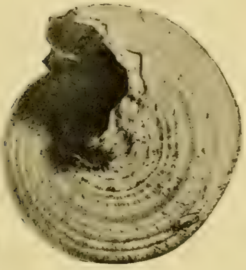

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* * *

A Stratigraphic Study of the Mollusks of the Calvert and Choptank Formations of Southern Maryland

A dissertation presented to the Faculty of the Graduate School of Bryn Mawr College in partial fulfillment of the requirements for the Degree of Doctor of Philosophy

By

Lois Margaret Schoonover

February 14, 1941

Paleontological Research Institution
Ithaca, New York
U. S. A.

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A STRATIGRAPHIC STUDY OF THE MOLLUSKS OF THE CALVERT AND CHOPTANK FORMATIONS OF SOUTHERN MARYLAND

by

Lois Margaret Schoonover

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INTRODUCTION

The following paper presents a restudy of the Miocene mollusks of southern Maryland with particular emphasis on their stratigraphic relationship and distribution. Many of the larger mollusks from the Maryland Miocene have been known since the first half of the nineteenth century, when they were described by Thomas Say, T. A. Conrad, and others. In 1904 G. C. Martin and L. C. Glenn published a monographic study of the molluscan faunas in the Miocene report of the Maryland Geological Survey. This report is now in need of considerable revision. Good, photographic illustrations are needed to replace the original drawings, and more adequate descriptions and comparisons of the species are conspicuously desirable.

The Maryland Miocene report gives no detailed information on the stratigraphic distribution of even the more common species. Species are usually cited as occurring in the "Calvert formation", or in the "Choptank formation", with no clue as to which part, or parts, of the formation is meant. Actually, a species may occur in one bed, throughout an entire formation, or throughout parts of two formations. Usually it is impossible to tell which is the case from the information given, although anyone who has done field work in the Miocene of southern Maryland can make a good guess as to the stratigraphic horizon from which a certain species has come. For example, if a species is cited as occurring in the Calvert formation south of old Plum Point wharf, it most probably came from "zone 10", since that is by far the most fossiliferous bed at that locality.

This paper is limited in scope to the more purely stratigraphic aspects of the problem. Its chief contributions are the factual information presented in the lists of species and in the distribution chart, and the detailed study of eleven genera of pelecypods. The species lists have been made as complete as possible for all of the localities and stratigraphic horizons visited by the writer. The chart of distribution shows the geographic and stratigraphic occurrence of the more important genera of pelecypods, as well as their relative abundance in each case. In this work, emphasis has been placed on those genera which were found to have stratigraphic importance in the field. Both the distribution chart and the method of detailed study of the pelecypods will be considered again in a later paragraph of this section.

The collections of this report were made by the writer during the summers of 1936, 1937, and 1938, mainly from the western shore of Chesapeake Bay in southern Maryland. Most of the localities are in Calvert County, a few are in St. Mary's, and one is in Charles County. In Calvert County, collecting was done principally along, or near, the western shore of the Bay, which for thirty miles has a N-S or NNW-SSE trend. Chesapeake Beach (Seaside) is the most northerly locality, and Drum Point the most southerly. The last, however, is in the St. Mary's formation, with which this report is only indirectly concerned. More properly, then, Camp Boy Haven may be taken as the most southerly collecting ground. In the writer's collecting only specimens in place, or in fallen blocks the source of which could not be mistaken, were taken.

A small collection of fossils was made from the Choptank formation along the south shore of the Potomac River in Westmoreland County, Virginia. Although W. C. Mansfield has attempted to correlate these beds with the Maryland zones, their exact correlation has not been definitely established. For that reason, as well as on account of the small size of the writer's collections, the Virginia fossils will not be discussed in detail.

The localities in Calvert County are along a series of high, eastward-facing cliffs, which overlook Chesapeake Bay, and which extend almost continuously from Chesapeake Beach to Drum Point. The lower parts of the cliffs are readily accessible, but the upper, stratigraphically higher, beds can usually be reached only where there are large fallen masses, up and over which one can climb. The constant and rapid wearing back of the cliffs, shown in the many falls and landslides, assures one of fresh exposures, and hence of unweathered fossils at many localities.

In a few instances, fossils have been collected from localities a mile or less inland from the Bay. New roadcuts offer the best opportunities, but fossils sometimes are brought to the surface during the plowing of fields. After such artificial exposures are a few years old, the fossils in them disappear, probably through rotting and leaching by near surface waters. A few inland localities mentioned in the Miocene report as exposing fossiliferous beds are now completely barren. Similarly, Dryden (personal communication) reported that when he was working at Hollin Cliff on the Patuxent River in 1929 there were numerous fossils present on the surface. The writer visited the same locality (number 13 in this report) in 1936 and again in 1938. The only fossils, aside from a few indurated blocks, which could be found at that time were obtained by digging a deep hole with a spade. The shells were all very rotten, and apparently in the process of being leached out.

The chart, herewith inserted, represents an attempt to express graphically (a) the vertical range, (b) the horizontal distribution, and (c) the relative abundance of all the pelecypods which have been found to have stratigraphic or other importance in the field. Of these three groups of data, the last has been

CHART

SPECIES ■ Abundant ○ Few ● Common × Rare ? Questionably identified "ZONE"	4	5-9					10												11,12,13			14						15	16		17										18		19							Undifferentiated Choptank						
LOCALITY NUMBER	40	42	41	40a	39	52	1 14 35	36	4	2	5	3 11 28	48	9	13	62	43	38				54	53	46	63	45	26		23	24	47	57	27	25	44	56	34	7	6 10 21	59	49	50	33	15	55	51	60	22	12			29	30	31	32	61
Glycymeris parilis							■	■	○	■	○	■	●	●																																										
Anadara subrostrata							●	●		●	○	●	●	●	○																																									
Anadara staminea																													×				■	●	○	○			○	○	●	●	●	●	●											×
Pecten humphreysii			○	×	○	×	○	○			×	○	×	×	○	×																																								
Amusium cerinum			×				×					×	×	×																																										
Chlamys coccymelus							×																																																	
Chlamys madisonius	○	○			○	○	■	●	●	●	●	■	■	○	●	○	■	■					●	●		●	●		○	○	○	●	●	●	○		●	■	■	○	○		●	■	■	■		●	●			●		○	○	○
Chlamys madisonius var. near marylandicus	×															×										×												○	○	○														×	×	
Chlamys marylandicus																																	○	○				○	○	○													×	×	×	
Astarte cuneiformis							■	●	○	■	●	●	●	●	●	○	○	○					×																																	
Astarte cuneiformis var. obesa							×	×		×			×	×																																										
Astarte cuneiformis var. calvertensis							×			×		×	×	×																																										
Astarte cuneiformis var. parma							×			×		×	×																																											
Astarte thomasii												○	○	○			●	○																																						
Astarte thisphila																													×			○	■	●	×	●	○	○	○	●													×			×
Astarte obruta																																							×	×	●		●	●	●	×						×				
Astarte exaltata										○		○	○	●			×																																							
Eucrassatella melina							●	●	○	●	○	■	●	●				○					×			×																														
Eucrassatella turgidula																													●	●		○	■	●	●	○		●	●	●	○														×	×
Eucrassatella marylandica																																											●	●	●	×										
Saxolucina foremani							○		○	●		●	■	■																																										
Saxolucina anodonta							■	●		●	○	●	○	○																	○		●	○	○			●	●	●			○	●	●							×				
Lucinoma contractus																										○	■		■	●			■		×				×																○	○
Diplodonta acclinis																							×						×			×	●	●					●	●				×												
Diplodonta subvexa																													×	×			●																							
Cardium leptopleurum							●	●		×				×																																										
Cardium craticuloide							×	×				×		×																																										
Cardium laqueatum												○	○	×													×						●					●	○					○												×
Isocardia marköei												×		×																																										
Isocardia mazlea										×		×		×																																										
Isocardia fraterna var. marylandica	○	○											?	?								○	●	■		●	●		○	○	○	○	■	○	○	○	○	○	○	○															○	
Isocardia ignolea																										×																														
Antigona staminea							●	○	○	■	●	■	■	■		×	○	○																																						
Chione latilirata							●	■		●	○	●		○			○	○																																						
Chione parkeria																						○	■	■	■	■																														
Corbula idonea							○		○	■		■	○	■			○						×			×						○	■	○	●	○	○		■	●	×		○	●	■		○					○				○
Corbula elevata			■	■	●		■	■		●	●	●	●	●	●	○	○																																							
Corbula inaequalis							●	●	○	●		●	●	●	●	●	○												○	○			●	●	●			●	●	●	●		○	○	○	○										
Corbula cuneata							×			×		×																					×	×	?				×	×				?												

found to be much the most difficult of representation. The greatest source of error lies in the wide variation in the ratio of total mass of shell material to the mass of matrix in any given bed. In "zone 10", a very fossiliferous bed, a species might be marked "few" or "rare", but the same number of specimens found in a relatively unfossiliferous bed might cause one to mark that species there as being "common". Consequently, the symbols for abundance of any species should be understood as being strictly comparable to one another for only the one particular bed in question. Of necessity, the personal element has loomed large in the making of this chart, and the final result represents no more than the writer's best judgment at the time the chart was constructed.

In the systematic descriptions of pelecypods, the method of treatment varies from group to group. The method which seemed best adapted to a clear presentation of the characters of a group has been used in each case. The principal aim has been to place emphasis on the relationships, both biologic and stratigraphic, of a group as a whole, rather than as a collection of separate species. For example, comparisons have been made among the range, distribution, and variations of all the species of the Astartes taken as a group, rather than giving a treatment of them individually and separately.

The method of study has been unusual only in the respect that it was based on exceptionally large suites of specimens. In each case in which detailed work is given in the systematic descriptions, the work was based on a study of several hundred specimens. For example, in the case of the Pectinidæ, the writer's suites consisted of over 500 specimens. The writer has about 300 specimens of *C. madisonius* from zone 10 of the Calvert alone, and more than 300 specimens of *Astarte* from different horizons. All of the specimens of one species, or of several closely-related species, were spread out on tables at the same time. In this way they were most accessible for study and comparison.

One result of the writer's use of this method has been the growing conviction that it is inadvisable to found species of fossils on a few unusual specimens. In many cases the range of variation in a species was found to be considerable. The extremes in any series of specimens could easily be selected as distinct species. However, in suites the size of those with which the writer was dealing every intermediate gradation was also present. Since complete series between the extremes could be arranged, the writer has been very hesitant to give even the extreme varieties new names. She has preferred to describe them simply as members of the main stock which vary in certain given directions. In several cases she has taken forms described as separate species by other authors and called them varieties of the main stock.

This wide range of variation is especially striking in the case of the *Astarte cuneiformis* stock, and in that of the *Chlamys madisonius* stock. Several species of *Astarte* allied to *Astarte cuneiformis* have been described by other authors, but for the reasons already given they are regarded here as varieties. In the case of the *Chlamys madisonius* stock several names have been applied to different variations. Even after an examination of the type specimens of some of these "species" the writer found it impossible to identify any of them positively among her collections. If they are at all common in the beds from which they were described, it could reasonably be expected that she would have found a few. The type specimens themselves are very similar to many forms in the writer's collections, but every gradation between these forms and the more central ones commonly regarded as *C. madisonius* is present.

It seems strongly inadvisable to burden the literature with new names for all the variations which can be recognized in so prolific a stock as, for example, *Chlamys madisonius*. Rather, it is sufficient for the present purpose to recognize that the forms do vary, both areally and stratigraphically, and to describe these variations. One group of variations in the *C. madisonius* stock, a variation which is described as approaching *C. marylandicus*, is illustrated on plates 2 and 3. These forms look quite distinct from typical *C. madisonius* as illustrated on plates 2, 4, and 5, and yet every gradation between them can be found.

In the synonymy of species no attempt has been made to give complete references to all citations of each species. The original description and a few subsequent references which added something of distinct value are the only ones included. Fuller synonymies have already been given in the Maryland Miocene report, and there seems to be little need for repeating them here.

The localities given for different species are those where the writer personally has found these species. The Maryland Miocene report summarized all the localities from which the different species had been reported up to the time of publication of that report, and little further work has been published since that time.

Almost no attempt has been made to identify the gastropods more accurately than could be done by reference to the Maryland Miocene volume. The writer is perfectly aware that many of the names used therein have since been revised, but the time involved in recognizing and applying such revisions as have already been made makes such work impracticable at the present. However, it is believed that such revisions are not indispensable for the purposes of this work. It will be sufficiently clear if it is understood that the present writer's reference to a species of gastropod is to that species as illustrated and described by Martin in the Maryland Miocene volume.

The same remarks apply to many of the pelecypods. Effort has been made to apply revised names of pelecypods in cases where this did not involve an excessive amount of time-consuming, bibliographic research. Mistakes may easily have been made in the application of revised names, or the writer may have accepted others' revisions without examining the evidence critically enough. However, she feels that such mistakes are not too vital for the purposes at hand, and she prefers to rely on the judgment of paleontologists who have had extensive taxonomic experience.

STRATIGRAPHY

The Miocene deposits in the Chesapeake Bay region form a broad band trending northeast to southwest from New Jersey, across Delaware, and the eastern and western shores of Maryland, into Virginia. In this report only that area of the Miocene lying in Maryland within the western shore counties of Calvert, St. Mary's, and Charles will be considered, and especial attention will be given to Calvert County. The Miocene beds of this area have been divided into three formations, Calvert, Choptank, and St. Mary's, from oldest to youngest, respectively. The St. Mary's formation is not the immediate concern of this report, though its stratigraphy and fossils will be mentioned incidentally.

All of the beds have a very gentle south or southeast dip, so that the oldest formation is exposed farthest inland, and the younger ones outcrop successively in a more southerly or southeasterly direction. The best exposures of the Miocene in all the Chesapeake Bay region are those of the Calvert Cliffs, known in the literature for well over a hundred years. In the thirty-mile stretch of the cliffs from Chesapeake Beach to Little Cove Point, the Miocene beds can be traced almost uninterruptedly. Probably less than a sixth of the entire distance is taken up by low-lying areas and valleys where tributary streams enter the bay.

This area has become a favorite place for the summer cottages of people living in Washington, Baltimore, and nearby places. As a result, reasonably good roads lead to the waterfront at intervals seldom exceeding two or three miles. The most difficult portions of the cliffs to reach are the stretches between Long Beach and the Cove Point lighthouse, and between Cove Point and Little Cove Point. Even here there are private roads by which one can reach the cliffs.

The lower part of the Calvert formation is exposed in the northernmost cliffs near Fairhaven in Anne Arundel County, and near Chesapeake Beach in Calvert County. The upper part outcrops from a short distance south of Chesapeake Beach to the mouth of Parker Creek . The Choptank formation is exposed best in the stretch between the mouth of Parker Creek and a short distance north of the Cove Point lighthouse, and the St. Mary's formation is well exposed near Little Cove Point. The latter formation is found from north of Cove Point lighthouse to Drum Point, but it is most fossiliferous over a stretch near Little Cove Point.

An historical summary of work relating to the Maryland Miocene is given in the Miocene report of the Maryland Geological Survey, and will not be repeated here. The first detailed subdivision of the section into zones was made by G. D. Harris[1] in 1893. Harris recognized what he called the Plum Point fauna, the Jones' Wharf fauna, and the St. Mary's fauna, and gave the more fossiliferous beds letters from *a* to *g*.

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[1] Harris, G. D.: *The Tertiary geology of Calvert Cliffs, Maryland;* Am. Jour. Sci., 3d ser., vol. 45, 1893, pp. 21-31.

In the Miocene report of the Maryland Geological Survey G. B. Shattuck divided the formations into numbered zones. The most abundantly fossiliferous beds correspond to Harris's lettered zones, but the less fossiliferous, intermediate beds are subdivided further. The Calvert formation includes zones 1-15, the Choptank zones 16-20, and the St. Mary's zones 21-24. The zones of the Calvert formation are grouped as two members, the Fairhaven diatomaceous earth, comprising zones 1-3, and the Plum Point marls, comprising zones 4-15. Zone 4, or the *Ostrea percrassa* bed, of the Miocene report corresponds to Harris's zone *a,* zone 10 to zone *b,* zone 14 to zone *d,* zone 17 to zone *e,* zone 19 to zone *f,* and zone 22 to zone *g.*

The Fairhaven diatomaceous earth does not carry many fossils. Those present are usually preserved as casts, or the shell substance is so rotten that it is practically impossible to collect them or to identify them accurately. Consequently it has been necessary to omit the Fairhaven diatomaceous earth from consideration in this paper.

Many of the "zones" recognized by Shattuck and the Maryland Geological Survey are not true paleontologic zones[2], but rather, beds. The principal shell beds are the only ones which could be designated as true paleontologic zones. Those beds which Harris designated as zones conform much more nearly to the definition of a paleontologic zone than do the intervening ones which were numbered by Shattuck. Of the zones designated by Harris, zone *d,* or zone 14, is the only one which is probably not a paleontologic zone.

Some of Shattuck's zones cannot be identified in the field. This is particularly true of the beds between the oyster bed, zone 4, and the thick shell bed, zone 10, and between the top of zone 10 and the bottom of zone 17 of the Choptank. Zones 5-9, inclusive, were differentiated on the basis of the relative abundance of the pelecypod, *Corbula elevata*. Even in the type locality it is almost impossible to recognize these zones. They are not well defined, and one must do considerable guessing to delimit them even where they were described. They have not been identified in any but this one locality. For the purposes of this report, then, zones 5-9 should be regarded as one bed. In the locality lists, and in the lists of occurrence of species these zones were given with question marks. The only reason or advantage in doing this was to show relative position within the bed composed of "zones" 5-9, and to make possible some comparison with Shattuck's divisions. Otherwise the entire thickness should be regarded as a single unit.

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[2] For a discussion of paleontologic zones, see Arkell, W. J.: *The Jurassic system in Great Britain,* Oxford, Clarendon Press, 1933, pp. 17-19.

The beds between zones 10 and 17 lend themselves somewhat more readily to subdivision. Zones 11 and 13 can be recognized over a considerable stretch of the cliffs as dense clay layers with prismatic jointing. Zone 12, between them, is a thin, sandy layer carrying quite a few fossils. The fossils are poorly preserved, and none were collected by the writer. However, this layer has yielded more vertebrate remains than any other bed. Zone 14 can be recognized best in the area between Parker Creek and Governor Run. Further north it is present, but it is so high in the cliffs that it is usually inaccessible. It can only be identified there by the fact that it carries more fossils than the enclosing beds. As one looks up at the higher portion of the cliffs zone 14 stands out as a band of shells. It is, however, never distinctly marked off from the enclosing beds. The only way the writer has ever found of delimiting it is by the relative rarity of fossils. There is no marked lithologic change, and the fossils do not stop abruptly, either above or below it.

The beds between zone 14 and zone 17 are even more difficult to differentiate. The writer has recognized zone 16 only in the area just north and south of Calvert Beach. Even here the bottom of the zone is not exposed. Elsewhere is seems impossible to differentiate the beds between zones 14 and 17. The writer has never been able to identify the supposed Calvert-Choptank unconformity, which should lie between zones 15 and 16, according to the Maryland Miocene report. In that report it is stated that the unconformity can best be seen from a boat in the area north of Governor Run. The writer has gone by boat along the stretch from Dares Beach to Parker Creek, and from Governor Run to Parker Creek, but never could she recognize anything to call an unconformity.

At one locality less than half a mile north of Scientists' Cliffs a colony of the echinoid, *Echinocardium orthonotum,* was found about 18 feet above water level, or about 2-3 feet above the top of zone 14. It is possible that this colony marks the "unconformity", but there is no proof that it does.

As previously mentioned, most of the localities from which the material used in this report was collected occur along a north-south, or linear, section. Very little is known about the extent of any of the Miocene beds, except the Fairhaven diatomaceous earth, inland from the Calvert Cliffs. Zone 10 is present at Hollin Cliff, localities 13 and 62, almost nine miles inland, and at the "Old Walls Place", locality 9, in Charles County, about 11½ miles west of the Bay shore. The Choptank formation with its fossiliferous beds, 17 and 19, is present near Jones Wharf on the Patuxent River in St. Mary's County, about nine miles directly west of the Bay shore in Calvert County. These are almost the only localities at which the zones described from the cliffs have been identified at any distance back from the Bay shore. The zones cannot be identified on the basis of lithology alone, and at most inland localities the fossils have been destroyed by rotting or leaching.

SYSTEMATIC DESCRIPTIONS

Phylum **MOLLUSCA**

Class **PELECYPODA**

Order **PRIONODESMACEA**

Family **GLYCYMERIDÆ**

Genus **GLYCYMERIS** da Costa

Glycymeris parilis (Conrad) Plate 1, figs. 1, 8

Pectunculus parilis Conrad, 1843, Acad. Nat. Sci. Philadelphia Proc., vol. 1, p. 306; 1845, Fossils of the Medial Tertiary, p. 64, pl. 36, fig. 2.
Glycymeris parilis (Conrad). Glenn, 1904, Maryland Geol. Survey, Miocene, p. 393, pl. 107, figs. 1-2.

Conrad's original description.—Orbicular, slightly oblique; height and length equal; posterior superior margin obliquely subtruncated; ribs defined by slightly impressed narrow radii; radiating striae minute and obsolete; marginal teeth prominent.

This is the only species of *Glycymeris* the writer has found in the Maryland Miocene. It is very abundant and characteristic of zone 10 of the Calvert, and so far has not been observed in any other bed. Even if future collecting should yield a few specimens from other beds, the species will remain a reliable marker for zone 10. Whenever it is found at all abundantly, one can be certain he is dealing with that zone.

This species commonly occurs in bands several inches thick within the main fossil zone. In these bands there are few other fossils; indeed, the shells are so closely packed together that the amount of sandy matrix is small. More than half of the specimens in these bands have the two valves still articulated, and the bands doubtless represent communities still in the position in which they lived. The bands are particularly well developed at a locality just north of Randle Cliff Beach, though they may be found almost everywhere zone 10 is exposed.

Dall reported *G. americana* from the Miocene of Calvert and Charles counties, Maryland, but this occurrence has not been verified, and it seems very questionable. This species is characteristic of the Upper Miocene in Virginia and North and South Carolina, of the Pliocene in North Carolina and Florida, and of the Pleistocene in South Carolina. It was not reported by Glenn from Maryland.

Glycymeris subovata (Say) is characteristic of the Yorktown and Duplin Miocene in Virginia, North and South Carolina. It was reported by Glenn from the Choptank formation at Greensboro, in Caroline County, Maryland, and at Davis's Mill on the Choptank, near Skipton, in Talbot County. In the collection of type and figured specimens of the Maryland Geological Survey at Johns Hopkins University there are two specimens labelled *Glycymeris subovata* Say, from Greensboro. One of these is figured as figures 3 and 4, plate 107 of the Maryland Miocene report, and the other is not figured. These two specimens are probably immature, but they are definitely different from *G. parilis.* The shell is thicker, more inflated, and longer in proportion to the height. The ribbing consists of narrow impressed lines, with the interareas very gently convex.

However, these two specimens do not correspond to specimens of G. *subovata* of similar size from Virginia. Young specimens of G. *subovata* are thinner and flatter. These two specimens seem to correspond most closely to young specimens of a new, undescribed species from the St. Mary's of Virginia, referred to by Mansfield (Florida Geol. Survey Bull. 8, page 40) as being very similar to G. *waltonensis* Gardner from the Shoal River formation of Florida.

Aside from these two specimens, the writer has never seen any specimens of *Glycymeris* from either the Choptank or St. Mary's formations in Maryland. If the genus is present in either of these, it is only as rare specimens, and it is not characteristic.

Of the three species, G. *americana,* G. *subovata,* and G. *parilis,* G. *parilis* averages the most convex, the greater convexity being particularly noticeable in the central region just below the umbones. Many specimens of G. *americana* and G. *subovata* seem to be of about equal convexity, though some series of G. *subovata* tend to be flatter.

In typical specimens the outline of the shell varies rather consistently in the three species. It is most nearly circular in G. *subovata.* In all three the greatest length of the shell is just ventral to a line connecting the outer ends of the hinge plate. The hinge plate, especially the central portion, is most strongly arched in G. *subovata,* least strongly in G. *americana.* It is intermediate in G. *parilis.* In G. *americana* the length is greater in proportion to the height, and the greatest length is confined to the dorsal half of the shell, after which it narrows down ventrally more rapidly than in the other two species.

The character of the ribbing in the three species is distinct. In G. *subovata* the ribs are fewer and broader. They are set off by sharply impressed lines, and the ribs between the lines are gently convex. In G. *parilis* the lines are more numerous but not so deeply impressed, and the ribs between the lines are flat. The ribs on G. *parilis* are not so apparent. In G. *americana* the impressed lines are still less distinct, and the ribs are almost flat. Each rib is crossed by very fine radiating striæ.

Figured specimens.—Nos. 3909 and 3915, Paleontological Research Institution.

Horizon.—Zone 10, Calvert Miocene.

Localities.—1, 36, 4, 2, 5, 3, 48, 9.

Family ARCIDÆ

Ten species of Arcidæ were reported by Glenn from the Maryland Miocene, but of these only four are abundant enough or distinct enough to be useful in stratigraphic field work. One of these occurs in the Calvert formation, one in the Choptank, and two in the St. Mary's. The species which Glenn gave, and their stratigraphic occurrences are listed below. The species which are here regarded as of stratigraphic importance are marked with asterisks.

Calvert formation
  *Arca (Scapharca) subrostrata Conrad
  Arca (Barbatia) centenaria Say
  Arca (Barbatia) marylandica Conrad

Choptank formation
  Arca (Scapharca) elnia Glenn
  *Arca (Scapharca) staminea Say
  Arca (Noëtia) incile Say
  Arca (Barbatia) centenaria Say

St. Mary's formation
  Arca (Scapharca) clisea Dall
  *Arca (Scapharca) arata Say
  *Arca (Scapharca) idonea Conrad
  Arca (Barbatia) virginiæ Wagner

Several of the species listed here are rare, or the report of their occurrence in Maryland was probably a mistake, so they may be dismissed with a few remarks. Glenn reported *Arca (Barbatia) centenaria* from both the Calvert and Choptank formations. It must be rare, however, since I have never found a single specimen. It is much more characteristic of the Yorktown Miocene of Virginia than of the Maryland Miocene.

Arca (Barbatia) marylandica occurs in the Calvert formation, probably in zone 10, but is also quite rare. W. C. Mansfield spoke of its being fairly common in zone 10 (personal communication), but I have failed to find a single specimen. Consequently no further information as to its range can be given here, though it seems likely that it is limited to zone 10.

Arca (*Scapharca*) *elnia* was described by Glenn from Jones Wharf, zone 17 at Governor Run, and 2 miles south of Governor Run. It was described as a species intermediate between *A. staminea* and *A. subrostrata.* This seems to be another rare, and not too distinct, species. I have collected one specimen only, which came from zone 10 of the Calvert formation from locality 28, south of Plum Point.

Arca (*Noëtia*) *incile* was reported from Maryland, but this was probably an error, as noted by MacNeil[3]. MacNeil says,

> Dall and the Maryland Geological Survey reported *E. incile* in the Burns and Harris collection from the Choptank formation at Jones Wharf, Md. This was evidently an error, as the specimens of this species in the Burns and Harris collection in the United States National Museum are recorded in the locality catalog as having come from Virginia and are like specimens from Rushmere Wharf in form and preservation. No collections from Maryland have contained any specimens of *Eontia,* to my knowledge.

I have not definitely identified any specimens of *Arca* (*Scapharca*) *clisea* from Maryland. Specimens of *Arca* from the St. Mary's formation at Langley's Bluff (locality 37) differ from the typical forms of *A. idonea* found on the St. Mary's River. They possess some characteristics belonging to *A. staminea* of the Choptank, and approach *A. clisea* in other respects. Their exact position and relationship have not yet been determined.

The occurrence of *Arca* (*Barbatia*) *virginiæ* in Maryland can be neither confirmed nor denied, but it is a rare species and much more characteristic of the Virginia Miocene. In the Maryland Geological Survey collections there is one much worn specimen labelled "Arca virginiæ Wagner", from "St. Mary's, Md." It is marked "Fig'd.", but is not the specimen figured in the Maryland Miocene report. It is a right valve, and is *Arca arata,* not *A. virginiæ.* The figure in the Maryland Miocene report is that of the exterior of the left valve of a type specimen, and the specimen should be in the Wagner Free Institute of Science.

There now remain for consideration only four species of Arcas which are regarded as of real stratigraphic value. Two of these occur only in the St. Mary's formation, and so do not belong

[3] MacNeil, F. S.: *Species and genera of Tertiary Noetinæ,* U. S. Geol. Survey Prof. Paper 189-A, 1938, p. 15. MacNeil assigned *Arca incile to* the new genus *Eontia* in this paper.

strictly within the scope of this report. These are *A. arata* and *A. idonea.* They both occur on the St. Mary's River and at Langley's Bluff. *A. idonea* is much less common at Little Cove Point than at the other two localities where the St. Mary's formation outcrops.

The two remaining species are *A. subrostrata,* which is confined to zone 10 of the Calvert, and *A. staminea* which occurs in zones 16-19, inclusive, of the Choptank. There appear to be no Arcas in any part of the Calvert formation except zone 10. *Arca subrostrata* is very common at practically every locality where this zone is found. Its absence from any of my localities for zone 10 is probably due to collection failure.

Arca staminea was found in zone 16 at one locality (23, N. of Calvert Beach). It is common in both zones 17 and 19, at almost every locality where they occur. It is common in zone 18 at locality 49, north of Scientists' Cliffs. At this place there is a thin band consisting almost exclusively of Arcas in clay at an elevation of 49½-52 feet above high tide, or 11 feet above the top of zone 17. At an elevation of 56-57½ feet there is another band of fossils in which *Arca staminea* is common. This band is about 3½ feet below the bottom of zone 19.

Within the principal shell beds (zones 10, 17, 19), both these species of *Arca* characteristically occur in thin bands consisting almost exclusively of a single species. The valves usually remain attached. Apparently the species were gregarious, and these bands represent colonies which were not washed about by waves or currents before burial. The individual bands cannot be traced any great distance (probably not more than a quarter of a mile), and they recur at different horizons within the shell beds at different localities. The individual bands appear to be more extensive in the Choptank than in the Calvert formation.

In general, *Arca subrostrata* can be regarded as a good index fossil for zone 10, and *Arca staminea* for the entire Choptank formation. The two species can be separated easily according to the characters indicated in the following key:

Elongate
  Ribs flattened, not noded, bearing radial sulci, usually one strong medial sulcus, with one or more shallower ones on each side .... *Arca subrostrata*
Not elongate
  Ribs elevated, rounded, often noded; radial sulci limited to one, if any on each rib........................ *Arca staminea*

Subfamily ANADARINÆ Reinhart

Genus ANADARA Gray

Anadara[4] subrostrata (Conrad) Plate 1, figs. 2-4

Arca subrostrata Conrad, 1841, Acad. Nat. Sci. Philadelphia Proc., vol. 1, p. 30; 1842, Acad. Nat. Sci. Philadelphia Jour., 1st. ser., vol. 8, pt. 2, p. 185; 1845, Fossils of the Medial Tertiary, p. 58, pl. 30, fig. 7.
Arca (*Scapharca*) *subrostrata* Conrad. Glenn, 1904, Maryland Geol. Survey, Miocene, p. 385, pl. 104, figs. 2, 3a, 3b.
Arca subrostrata Conrad. Sheldon, 1917, Palæontographica Americana, vol. 1, No. 1, p. 51, pl. 12, figs. 1-4.

Conrad's original description.—Ovate; profoundly ventricose; ribs about 30, little prominent, flat, longitudinally sulcated; posterior side produced, cuneiform; rounded at the extremity; hinge linear in the middle, teeth obsolete, except towards the extremities; within slightly sulcated; crenulations of the margin sulcated in the middle. Length 2 inches.

Specimens from localities 35 and 36, north and south of Randle Cliff Beach, average slightly larger than those from other localities. Young specimens are commonly less elongate than the adult shells, and occasionally are very similar in general shape and outline to *A. staminea*. *A. subrostrata* is usually thinner-shelled than *A. staminea*. The ribs on *A. subrostrata* only ve rarely bear nodes.

Figured specimens.—Nos. 3910-3912, Paleontological Rese Institution.

Horizon.—Zone 10, Calvert Miocene.

Localities.—35, 36, 2, 5, 3, 48, 13, 9.

Anadara staminea (Say) Plate 1, figs. 5-7; plate 2, fig. 4

Arca staminea Say, 1832, Amer. Conch., part 4, pl. 36; fig. 2.
Arca elevata Conrad, 1840, Fossils of the Medial Tertiary, No. 1, cover.

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[4] According to Reinhart's classification (1935), this and the following species, *A. staminea,* should be assigned to the genus *Anadara*. In the foregoing discussion the list of species was quoted from the Maryland Miocene report, and it seemed best to retain Glenn's terminology for all of the species for the sake of clearness in that discussion. Hence, *Arca subrostrata* and *Anadara subrostrata* are the same species, as are *Arca staminea* and *Anadara staminea.*

Arca callipleura Conrad, 1840, Fossils of the Medial Tertiary, p. 54, pl. 29, fig. 2.
Arca triquetra Conrad, 1843, Acad. Nat. Sci. Philadelphia Proc., vol. 1, p. 305.
Arca (*Scapharca*) *staminea* Say. Glenn, 1904, Maryland Geol. Survey, Miocene, pp. 387-88, pl. 105, figs. 2-6; Sheldon, 1917, Palæontographica Americana, vol. 1, No. 1, pp. 39-40, pl. 9, figs. 7-13.

Say's original description.—Shell thick, prominently convex; with about twenty-eight ribs which are rounded and narrower than the intervening spaces, excepting on the anterior side, where they are broader, and simply wrinkled, those of the anterior part of the disk have one or two longitudinal impressed lines; they are crossed by numerous transverse, elevated lines, which are hardly more distant from each other than their own width; intervening spaces wrinkled: beaks distant, curved a little backward, and the tip a little behind the middle of the hinge margin; area flattened, a little curved, rather spacious, with obvious impressed, oblique lines: hinge margin rectilinear, with small, numerous teeth: posterior margin regularly arcuated: base subrectilinear, very deeply crenated: anterior margin oblique, rectilinear; anterior side abruptly compressed.

This species is thicker-shelled than *A. subrostrata.* The ribs are more elevated and rounded, and the nodes are much more commonly developed, though they are not present on all specimens. The radial grooves are limited to a single groove on each rib.

Specimens show some variations in different beds and different localities. In general, specimens from zone 19 have a diameter which is greater in proportion to other dimensions of the shell than in those from zone 17. The latest growth of the shell takes place along all margins at an angle approaching a right angle to the plane between the valves. The cardinal area is accordingly widened. This gives a much inflated shell, with a diameter greater in proportion to its other dimensions than in shells from zone 17.

The Jones Wharf specimens are less inflated, their cardinal area is narrower, the shell substance less thickened, and the outline is less squarely compressed anteriorly and posteriorly. The same is true of specimens from locality 44, north of Long Beach, and from locality 25, south of Calvert Beach. It is not so striking in specimens from locality 27, north of Calvert Beach, or from locality 56, south of Flag Pond. These specimens show considerable variation, with some shorter, higher, and more inflated forms than from zone 17 at other localities. Individual specimens probably could not be separated from those of zone

19, but a suite of specimens from zone 17 is less consistent in shape and outline and could probably be separated. Specimens from zone 19 seem to have sharper angles at the junction of the anterior and dorsal, dorsal and posterior, posterior and ventral margins.

Some of these variations have been described as separate species, as noted by Sheldon and Glenn. Glenn said, "A careful comparison of what are doubtless the type specimens of *A. callipleura* shows that it is but a short, elevated, thickened, and well sculptured form of *A. staminea*." Sheldon added, "*A. triquetra* Conrad is a short, high and little sculptured form of *A. staminea*."

The specimens from zone 18 apparently belong to the short, high type of zone 19. The sulcus Sheldon spoke of as being just anterior to the umbonal ridge is not very noticeable in any of my specimens, and is entirely absent from the short, high forms characteristic of zone 19.

Figured specimens.—Nos. 3813, 3914, and 3919, Paleontological Research Institution.

Horizons.—Zones 16-19, inclusive, Choptank Miocene.

Localities.—23; 59, 6, 10, 21, 27, 25, 44, 56; 50, 49; 33, 55, 15.

Family PECTINIDÆ

Four groups of Pectinidæ are present in the Calvert and Choptank formations of southern Maryland. Two of these are represented by relatively rare specimens, but they are so distinct that they could not be confused. These two groups are *Pecten, s. s.,* represented by *Pecten* (*Pecten*) *humphreysii* Conrad, and *Amusium,* represented by *Amusium* (*Pseudamussium*) *cerinum* (Conrad). The first of these occurs in the lower part of the Calvert formation, zone 4 up through zone 10, but has not been recorded from any beds above zone 10. The second occurs chiefly in zone 10. I also collected one specimen from zone 6? north of Randle Cliff Beach. The species was reported by Glenn from the Choptank formation at Jones Wharf, but with the exception noted here I have not seen specimens from any beds other than zone 10 of the Calvert.

The third group is included in the subgenus or section *Placopecten,* and is represented by *Chlamys* (*Placopecten*) *marylandicus* (Wagner). This species is fairly common in zone 17 of the Choptank formation, and so far as I am aware no authentic specimens have been recorded from any other bed. A few specimens from the Calvert formation have been found which would be taken for *C. marylandicus* at first glance, but they are not identical. Some series of *C. madisonius* from the Choptank show variations in the direction of *C. marylandicus,* but these can always be separated from the true *C. marylandicus.*

The fourth group is that of the subgenus *Lyropecten.* It is by far the most common group of Pectens in the Maryland Miocene, and its chief representative, *C. madisonius,* is also one of the most common mollusks. *C. madisonius* might better be regarded as a stock or lineage than as a species, because of its many variations. Several species and subspecies belonging to this stock have been described, but they are all so similar that they are difficult to differentiate. The species and subspecies which have been described from the Calvert and Choptank formations are shown in the following chart.

Pecten (Pecten) humphreysii Conrad Plate 2, figs. 1-2

Pecten Humphreysii Conrad, 1842, Proc. Nat. Inst., Bull., vol. 2, p. 194, pl. 2, fig. 2.
Vola Humphreysii Conrad. Whitfield, 1894, U. S. Geol. Survey Mon. 24, p. 32, pl. 4, figs. 6-9.
Pecten (*Pecten*) *humphreysii* Conrad. Glenn, 1904, Maryland Geol. Survey, Miocene, p. 372, pl. 98, figs. 10-12; Tucker, 1936, Am. Midland Naturalist, vol. 17, No. 2, p. 478, pl. 3, fig. 3, pl. 4, fig. 10.

Conrad's original description.—Suborbicular, inferior valve convex; superior flat, and with about seven remote, narrow, convex ribs, and concentrically wrinkled; towards the apex is a concave depression; ears equal, sides direct and straight; inferior valve with the ribs wide, approximate, plano-convex and longitudinally striated; one of the ears emarginate at the base.

This species is never very abundant, but careful collecting will usually yield a specimen or two from the beds between the oyster bed and zone 10, and from zone 10 itself. In Maryland the species is apparently limited to these beds, and has never been reported from above zone 10. It is a very distinct species, and could not be confused with any other.

	Genus PECTEN	Genus CHLAMYS		Genus AMUSIUM
	Subgenus PECTEN	Section PLACOPECTEN	Subgenus LYROPECTEN	Subgenus PSEUDAMUSSIUM
ST. MARY'S			santamaria	
CHOPTANK		marylandicus	madisonius near marylandicus madisonius, s. s.	?
CALVERT	humphreysii		madisonius near marylandicus madisonius, s. s. madisonius bassleri madisonius acanikos coccymelus	cerinum

Figured specimens.—Nos. 3916 and 3917, Paleontological Research Institution.

Horizon.—Zones 4-10, Calvert Miocene.

Localities.—41, 40a, 52, 39; 1, 36, 5, 3, 48, 13, 62, 9.

Chlamys (Placopecten) marylandicus (Wagner) Plate 3, figs. 4-5

Pecten marylandicus Wagner, 1839, Acad. Nat. Sci. Philadelphia Jour., 1st ser., vol. 8, p. 51, pl. 2, fig. 2 (numbered fig. 2 on plate, fig. 1 in text).

Pecten (Placopecten ?) marylandicus Wagner (part). Dall, 1898, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 728.

Pecten (Chlamys) marylandicus Wagner. Glenn, 1904, Maryland Geol. Survey, Miocene, p. 376, pl. 99, fig. 6.

Chlamys (Placopecten) marylandicus (Wagner). Tucker-Rowland, 1938, Mus. roy. Hist. nat. Belgique, Mem., 2d ser., fasc. 13, p. 54, pl. 4, fig. 13, pl. 5, fig. 16.

Wagner's original description.—Shell ovate, compressed; ribs numerous, consisting of narrow, nearly smooth striæ, disposed in pairs; interstitial spaces each with a carinated line; ears unequal; inferior valve very slightly convex; ribs similar to those of the opposite valve; inner margin of the valve with profoundly elevated lines.

Locality. Mehering river, North Carolina. This Pecten is allied to Pecten *Madisonius*, Say, but can readily be distinguished by its want of broad, elevated ribs, and a surface destitute of scales; several specimens of Spirorbus *nautiloides*, Lam., are attached to the surface of the superior valve.

Wagner's locality was probably wrong, since the species is known only from the Choptank formation of Maryland and Virginia. In the Philadelphia Academy there are two trays of *C. marylandicus*, each tray containing three specimens. So far as the present writer can determine, either or both of these could have been Wagner's original material. In one tray there are two labels, one saying "Patuxent River, Maryland", which is probably correct, and the other "N. Car. Pliocene?", which must be a mistake. In the second tray no locality is given.

Wagner's original figure was of a left valve, but the drawing was extremely poor. It would be difficult to determine the species from the drawing, and one could never identify the specimen from which the drawing was made. A right valve in the first tray bears several specimens of *Spirorbis* and may be the specimen to which reference was made in Wagner's description. A penciled note inside the shell indicates that this should be the specimen figured, but this is a right valve, and the one figured was a left valve. A second specimen in this tray corresponds in size with the original figure.

Mrs. Tucker-Rowland selected a right valve from the second tray as one which she thought might be the holotype. If a holotype existed, it would have to be a left valve, because the original figure was of a left valve. Mrs. Tucker-Rowland indicated that the specimen she chose was from the type locality and was identified by Wagner, but no locality is given in the tray with that specimen, and it is very questionable whether any of these specimens actually came from the Meherrin River, North Carolina.

Mrs. Tucker-Rowland gives measurements for the "holotype" as height, 76, width, 69 mm. Wagner gave no measurements, and the measurements above appear to have been taken from the specimen figured by Mrs. Tucker-Rowland. However, the width is not the maximum width for that specimen, the maximum being 77 mm. If one is to give any measurement other than the maximum for the width or length of a *Pecten,* that measurement has almost no meaning because it can be varied so as to yield any value from the maximum down to zero.

True *Chlamys marylandicus* occurs only in the Choptank formation, and, so far as this writer has observed, only in zone 17 of the Choptank. It occurs in the Choptank of the Nomini, Stratford, and Horsehead Cliffs of Virginia, but the Choptank has not been well differentiated as to zones in these localities. The ribbing of *C. marylandicus* is its most distinctive feature, and it usually serves to differentiate it from other Maryland Miocene Pectens at a glance. The ribbing consists of radial lines which tend to group themselves into major ribs of varying degrees of prominence.

In true *C. marylandicus* the lines occur in pairs, each pair alternating with a single line. All the lines are about equidistant, but the paired lines are slightly more elevated than the intervening single line, and so form a slightly elevated major rib. This major, exterior ribbing is reflected on the interior of the shell.

Toward the ventral margin of the largest specimens another faint line may appear between the paired lines; also one on each side of the major rib at its base. The exterior of the shell is covered by an extremely fine concentric sculpture which extends between the radial lines but does not cross them.

Several series of specimens of *C. madisonius* from the Calvert (locality 40, zone 4, south of Randle Cliff Beach; locality 62, zone 10, Hollin Cliff) and Choptank (Jones Wharf, Md., and Stratford Cliffs, Va.) formations show striking similarities to *C. marylandicus* and could at first be mistaken for that species. These forms have similar radiating lines, but they are not so evenly spaced. Groups of three, instead of two, alternate with a single line, and the ribs formed by the three-groups are often more elevated than the similar ribs in *C. marylandicus.* The spaces between the lines of the three-groups are narrower than those between these groups and the single lines of the interareas. The general appearance of the two shells is such that in true *C. marylandicus* the effect is that of a relatively smooth surface with many radiating lines. In the variety the major ribs are more prominent, and the appearance is that of *C. madisonius* without the scaly structure. Both *C. marylandicus* and the variety of *C. madisonius* are illustrated on plate 3.

Figured specimens.—Nos. 3925, 3926, Paleontological Research Institution.

Horizon.—Zone 17, Choptank Miocene.

Localities.—27, 25, 7, 6, 59.

Chlamys (Lyropecten) madisonius (Say) Plate 2, figs. 3, 5-6; Plate 3, figs. 1-3, 6; Plate 4, figs. 1-4; Plate 5, figs. 1-3

Pecten madisonius Say, 1824, Acad. Nat. Sci. Philadelphia Jour., 1st ser., vol. 4, p. 134; 1896, Harris Reprint, Bull. Amer. Paleont., vol. 1, No. 5, p. 40; Conrad, 1840, Fossils of the Medial Tertiary, p. 48, pl. 24, fig. 1.

Pecten (Chlamys) madisonius Say. Glenn, 1904, Maryland Geol. Survey, Miocene, p. 377, pl. 100, fig. 1.

Chlamys (Lyropecten) madisonius (Say). Tucker-Rowland, 1938, Mus. roy. Hist. nat. Belgique, Mem., 2d ser., fasc. 13, p. 9, pl. 1, figs. 1-2; pl. 4, fig. 8.

Say's original description.—Much compressed, with about sixteen striated ribs.

Shell rounded, much compressed; the whole surface covered with scaly striæ: ribs elevated, rounded, with about three striæ on the back of each; intervening grooves rather profound: ears equal, sinus of the ear of the superior valve profound, extending at least one third of the length of the ear.

Length rather more than four inches and a half; breadth four inches and four-fifths.

In magnitude this shell is justly entitled to compare with the preceding (*P. jeffersonius*); but it differs in being much less convex, and in having a much more profound sinus in the ear of the superior valve. Three specimens, from which the above description was taken, belong to the Academy, and were presented by Mr. Watson.

Mrs. Tucker-Rowland figured and described a young specimen from the U. S. National Museum which she thought might be the holotype, though she did not indicate why she chose this specimen. She gave as dimensions of this specimen height, 46 mm., width, 41 mm. In his original description Say gave the dimensions as length over 4½ inches (114 mm.), and breadth, 4 4/5 inches (122 mm.). If any holotype exists it would have to have those dimensions.

Say's specimens should be in the Academy of Natural Sciences of Philadelphia. His original description indicated that it was based on three specimens. Search in the Academy has failed so far to locate these specimens. The only specimen with Say's label is not *C. madisonius,* but probably *C. jeffersonius edgecombensis.* The label indicates that the specimen came from St. Mary's River, Maryland, but this is probably a mistake, and it more likely came from Virginia.

The specimens figured by Mrs. Tucker-Rowland (pl. 1, figs. 1-2) as *C. madisonius* probably did not come from the St. Mary's formation, on St. Mary's River, Maryland, but from the Choptank formation. Although I have not seen the actual specimens, the illustrations are typical of Maryland Choptank torms, and I have not seen specimens like Mrs. Tucker-Rowland's from the St. Mary's formation anywhere in Maryland.

C. madisonius is one of the most characteristic species in the Maryland Miocene. It occurs throughout the Calvert and Choptank formations, but not in the St. Mary's. The species shows many variations in different beds and in different localities. The chief variations which can be observed relate to the following characters:—size, length-height ratio, thickness of shell substance, degree of prominence of the scaly sculpture; distance from the beak at which the scaly sculpture begins; number and prominence of major ribs; number of radial striæ; the angle from the umbo to the anterior and posterior margins; degree of concavity of the dorsal slopes from the umbo.

The literature dealing with the occurrence and characteristics of this stock is fairly extensive, but it occurs in scattered publications and in such unorganized form that it is difficult to understand and to use. Four species or subspecies of the *madisonius* stock have been described from the Calvert formation:

C. madisonius (Say), *s. s.*
C. madisonius bassleri Tucker-Rowland, 1938
C. madisonius acanikos (Gardner) Tucker-Rowland, 1938
C. coccymelus (Dall), 1898

A careful study of many specimens from different localities indicates that there are two more groups not included among these, which deserve recognition. One of these is a group resembling *C. marylandicus* but distinct from that species and showing transitional stages from *C. madisonius*. The other group is a small, thin, flat variety of *C. madisonius* found abundantly in zone 10 at the north end of the Calvert Cliffs, near Randle Cliff Beach, and becoming progressively more rare away from that locality.

It is impossible to state whether any of the Maryland Calvert forms are really identical with *C. acanikos* Gardner from the Chipola Miocene of Florida, because of lack of adequate material from Florida for comparison. Mrs. Tucker-Rowland regarded *C. acanikos* Gardner as a subspecies of *C. madisonius* Say, and stated that it is rather common at Plum Point. The Florida form is certainly very close to some of the forms from zone 10 of the Calvert.

C. coccymelus (Dall) is a rare species, and never abundant enough to be of stratigraphic value. The type was stated by Dall to have come from Plum Point, Maryland; hence it probably came from zone 10. The chief characteristic of this species is the single row of spines on each rib. The height of the shell is slightly greater in proportion to the length, and consequently the umbonal angle smaller than in typical *C. madisonius*. The holotype may not be a full-grown adult.

C. madisonius bassleri Tucker-Rowland is an unusually spinose variety of *C. madisonius*, characterized by three rows of spines on each rib, the center row being more prominent than the other two. The presence of three scaly radials on each rib is quite characteristic of *C. madisonius* and would not serve to differentiate this subspecies from *C. madisonius.* The degree to which the scales are developed into spines seems to be the distinguishing character. The umbonal angle is slightly greater than in *C. coccymelus,* and so the outline of the shell is close to that of *C. madisonius* from the Calvert.

The holotype came from Plum Point, and the subspecies was also reported from Chesapeake Beach. The stratigraphic occurrence is probably zone 10 in each case.

A study of the specimens in my collections indicates that this subspecies simply represents one extreme in the many variations of the *C. madisonius* stock in the Calvert formation. It is not an outstanding, clear-cut subspecies, since it can only be separated by a minute comparison of many specimens with the original description and type material. It is too rare and too indistinct to be of stratigraphic value.

The comparisons which Mrs. Tucker-Rowland made under the heading of "Remarks" in her original description of *C. madisonius bassleri* are unfortunate and confusing. This paragraph is quoted here:

> *C. madisonius bassleri* is smaller, and the shell is thinner than that of *madisonius, s.s.* The development of scaly sculpture is more pronounced; ribs more numerous and narrower; left valves more convex; more nearly oval in outline. This subspecies tends to be larger than *coccymelus,* has fewer ribs; a single row of scales on the summits of the ribs; less conspicuous scaly sculpture; longer hinge line; more strongly convex. This subspecies appears to be quite characteristic of the Maryland Calvert.

Mrs. Tucker-Rowland states in the paragraph quoted above that the ribs are more numerous in the subspecies than in *madisonius, s. s.* The subspecies carries 16 ribs. This is the same number Say gave in his original description for *madisonius;* it is the same number Mrs. Tucker-Rowland gives in her description of the "holotype" of *madisonius* (but which could not be the holotype, as pointed out above). Mrs. Tucker-Rowland then gives the number of ribs as varying from 14 to 17 in her more general description of *madisonius.* Evidently the number of ribs could not be relied upon to separate the two.

In comparison with *C. coccymelus* Mrs. Tucker-Rowland implies that a single row of spines on the ribs is a distinguishing character of the subspecies *bassleri*. The single row of spines on the ribs was the most conspicuous identifying characteristic of *C. coccymelus*. Mrs. Tucker-Rowland's holotype of *C. madisonius bassleri*, in the National Museum, bears three rows of spines on each rib, the central one more prominent than the other two. An examination of the type specimens of both *C. coccymelus* and *C. madisonius bassleri* shows that it is *C. madisonius bassleri* which has the more conspicuous scaly structure, for in this subspecies the scaly radials cover not only the top of the ribs but also extend down their sides and across the interspaces. In the type of *C. coccymelus* there is only a single row of spines on the ribs, and the interspaces are smooth except for a single, extremely fine, beaded radial, and a second fine radial about 5 mm. from the ventral margin.

It is not wise to rely too fully on the difference between one and three scaly radial striæ, or rows of spines, on the major ribs. Often in young stages a single row appears first, and in more mature parts of the specimens an additional row appears on each side of the first. Hence, young specimens commonly show a single row of spines, and more mature ones three. There is also considerable variation in the degree of development of the second and third rows. Sometimes they are developed almost equally with the first row, and at other times they are much less well developed. Similarly there is considerable variation in the number and degree of development of the scaly radials in the interspaces.

The general appearance of suites of specimens from different beds and localities varies, and it is possible to make some distinctions between such suites. These distinctions would not hold for individual specimens, but in large suites they are apparent.

C. madisonius was reported by Shattuck from "zone 2" of the Calvert formation on a branch of Lyons Creek. It occurs in the oyster bed, zone 4, and from there up through the Choptank formation. It is noteworthy that in the lower beds of the Calvert formation the specimens are much smaller than those in the Choptank. The largest specimens this writer has collected from zones 4-10 of the Calvert scarcely exceed 80 mm. in height, and specimens of this size are not nearly so common as those about 60 mm.

or less in height. In zone 14 of the Calvert specimens averaging 100-125 mm. in height first become common. In zone 17 of the Choptank formation, the specimens are of similar size to those in zone 14, but in zone 19 they are larger and heavier, the height commonly reaching 140 mm.

In the oyster bed, zone 4, only small specimens less than 40 mm. in height are common. The scaly radial striæ so common on specimens from other beds and localities are much less well developed. Along with these occurs *C. madisonius*, variety, which resembles *C. marylandicus* so strongly that it would at first be mistaken for that species. The only specimens of this variety collected here are so distinct from *C. madisonius* that they would never be mistaken for that species, although similar forms in the Choptank show almost every gradation into *C. madisonius.* In the specimens from zone 4 the major ribs are only very slightly elevated. Each is covered by three radial threads, and there are about three radial threads in the interspaces. The general effect is that of a smooth surface covered by fine radial threads.

In the beds between the oyster bed, zone 4, and zone 10, there are a few small specimens of *C. madisonius* scattered throughout, but they are not abundant. Those that are present are similar in character to those from zone 4. It seems possible that there is some relation between the development of these shells and the lithology of the containing beds. These beds, zones 4 through 9, are fine-grained, bluish, sandy clays, with some diatomaceous material. Zone 16 of the Choptank is similar in appearance, and in it the Pectens show a similar development—the specimens are small, relatively smooth, and with sharply elevated ribs. Probably the environmental conditions which affected the type of sediment also affected the life forms and resulted in similar developments. My observations on the variations in the specimens found in these beds are not so dependable as those on specimens from zones 10, 14, 17 and 19, however, because the suites of specimens available for study are not nearly so large as in the latter cases.

The following observations on the variations in the *C. madisonius* stock within zone 10 are based on a study of over three hundred specimens from various localities. The first and most striking thing about the forms from zone 10 is their small size. The average specimen is less than 70 mm. high. On the other hand, if they are compared with young specimens of similar size from zones 17 and 19 of the Choptank, where the species attains a much greater size, they can usually, if not always, be separated.

Perhaps the forms from the beds below zone 14 of the Calvert should be separated as a species or subspecies distinct from *C. madisonius, s. s.* of the Choptank on the basis of size and other differences. The Calvert forms from zone 10 certainly show consistent differences and are not identical with the typical large *C. madisonius* from zones 17 and 19 of the Choptank. There would be no mistaking large suites of specimens from the Calvert below zone 14 and those from the Choptank. Whether these differences are important enough to be given specific or subspecific rank is uncertain, and so they are merely described here without giving them new names.

The chief variation observed in specimens of *C. madisonius* within zone 10 is that at the north end of the Calvert Cliffs a thin flat variety occurs which becomes much less common the further one goes away from the area just north of Randle Cliff Beach. This variety is illustrated on plate 4, figures 1-3. It possesses a thinner shell and is less convex than *C. madisonius* elsewhere in zone 10. The dorsal slopes from the umbo are very nearly straight lines, and not so concave as in *C. madisonius* from other localities, such as Plum Point. The height is greater in proportion to the length of the specimen in the variety. There are three scaly radial threads on each rib which are more uniform than in *C. madisonius* from zone 10 elsewhere. The scaliness begins quite early, usually within 10 mm. from the beak. In the interspaces there is one central, fine scaly thread, with one or more still finer ones on each side of it.

About half of the specimens collected from locality 1, north of Randle Cliff Beach, belong to this variety. It is interesting to note that almost all the specimens of this variety are of a very light, yellowish-tan color, while those which are more like the forms which occur in zone 10 at Plum Point are also more like them in color, being darker and more grayish. Color certainly could not be regarded as a reliable character for determining a variety of a fossil species, but it is rather striking that the color does coincide with other characters in this case.

Some young specimens from the Choptank formation at Jones Wharf approximate this variety in shape, but lack the characteristic scaly sculpture, or else the scaliness does not start nearly so early.

In specimens of *C. madisonius* from most beds and localities the dorsal slopes from the umbones are straighter in young specimens, and become more concave in adults. They form nearly straight lines in many specimens from zone 10 near Randle Cliff Beach, but are more concave in specimens from Plum Point. In many large specimens from the Choptank these lines change their direction with growth so that in the last stages they begin to approach parallelism with the hinge line itself.

A suite of specimens from Plum Point compared with a suite of specimens of similar size from Jones Wharf shows certain differences. In general, the ribs of the Plum Point specimens are more sharply elevated; the umbonal region is more convex; the length is greater in proportion to the height than in specimens of similar size, but not in proportion to adult specimens; the Plum Point specimens lack the fine, smooth radial lines common on Jones Wharf forms.

Between Plum Point and Dares Beach there is a thin shell layer at the top of zone 10 which is slightly separated from the main mass of the zone itself. In specimens from this layer the scaly sculpture is rather well developed and much more uniform over the entire surface, ribs and interareas, than in specimens from other beds. Some of the very large specimens from zones 17 and 19 of the Choptank have scaly sculpture which is equally uniform, but coarser.

A few specimens from zone 14 approach *C. sayanus* from the Oak Grove Miocene of Florida in the great length of the shell, and in the manner in which the ribs become flattened and almost obsolete toward the ventral margin. The sand in zone 14 carries a considerable admixture of mud, and the shells are not so well preserved as in the more purely sandy beds. Consequently the surface of specimens from this bed is usually weathered and the scales gone. On the specimens which do retain the scales, they seem to be fairly fine and evenly distributed, similar to those on specimens from the top of zone 10, referred to above.

The number of ribs is quite variable in specimens from within the same bed and in specimens from different beds. There is a slight tendency toward a smaller average number of ribs in zone 19 of the Choptank. Specimens from zone 10 at Plum Point have a range of 16 to 19 at least. About equal numbers of specimens have 17 and 18 ribs, and the next most abundant have 16. Specimens of the new variety from zone 10 north of Randle Cliff have a range of 17 to 19, 17 and 18 being most common. In zone 19 the common range is 13 to 18, with the majority of specimens bearing 14-16. Such differences could not be regarded as very dependable, and would be of no use in determining species. They are interesting, however, because they appear to continue the trend of reduction of the number of ribs found in the line from *C. madisonius,* through *C. santamaria,* to *C. jeffersonius.*

Chlamys madisonius

Figured specimens.—Nos. 3918, 3921, 3931-34, Paleontological Research Institution.

Horizons.—Zones 4-19, Calvert and Choptank Miocene.

Localities.—Zones 4-9, localities 42, 40, 39, 52. Zone 10, localities 1, 36, 4, 5, 2, 3, 43, 38, 62, 13, 9. Zone 14, localities 53, 46, 45, 26. Zone 16, localities 23, 24. Zone 17, localities 47, 57, 34, 27, 25, 44, 7, 6, 59. Zone 18, locality 49. Zone 19, localities 33, 15, 55, 51, 22, 12.

Chlamys madisonius, variety approaching *marylandicus.*

Figured specimens.—Nos. 3920, 3922-3924, and 3927, Paleontological Research Institution.

Horizons.—Zones 4, 10, 14, Calvert; zone 17, Choptank Miocene.

Localities.—40; 62; 45; 7, 59, 6. Undifferentiated Choptank, 31, 32.

Chlamys madisonius, variety.

Figured specimens.—Nos. 3928-30, Paleontological Research Institution.

Horizon.—Zone 10, Calvert Miocene.

Localities.—1, 36, 5.

Chlamys coccymelus

Horizon.—Zone 10, Calvert Miocene.

Locality.—1.

Amusium (Pseudamussium) cerinum (Conrad)

Pecten cerinus Conrad, 1869, Am. Jour. Conch., vol. 5, p. 39, pl. 2, fig. 2.

Pecten (*Pseudamusium*) *cerinus* Conrad. Dall, 1898, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 753; Glenn, 1904, Maryland Geol. Survey, Miocene, p. 373, pl. 99, fig. 2.

Amusium (*Pseudamussium*) *cerinus* (Conrad). Tucker-Rowland, 1938, Mus. roy. Hist. nat. Belgique, Mem., 2d ser., fasc. 13, p. 68, pl. 5, fig. 11, pl. 6, fig. 8.

Conrad's original description.—Subovate, extremely thin, compressed; ears equal; right valve radiately ribbed; ribs very slightly raised and rounded; surface ornamented by minute, close divaricating lines, left valve without ribs.

Dall, 1898.—Shell small, thin, polished, compressed; left valve more convex, with about twenty faint, flat, rather irregular obsolete ribs, separated by narrower, shallow sulci, the whole surface with minute Camptonectes striation; right valve with concentric incremental lines and a few faint threads near the beaks and anterior submargin; ears small, subequal; ctenolium present; cardinal and auricular crura developed; interior of left valve faintly fluted, but without liræ. Alt. 19, lat. 18 mm.

In some of the specimens there are a few feeble concentric undulations near the beak of the left valve.

This is always a very rare species. It is quite fragile, so that when it is found it is usually broken. I have collected seven specimens from locality 9 in Charles County, and one specimen from each of the other localities listed below.

Horizons.—Zones 6?, 10, Calvert Miocene.

Localities.—41; 35, 3, 48, 9.

Order TELEODESMACEA

Family ASTARTIDÆ

Genus ASTARTE Sowerby

The conditions for *Astarte* evolution during Miocene time must have been extremely favorable, and a profuse development of both species and individuals resulted. The common species show a great amount of variation so that in a collection with only the extremes represented they would be accepted without hesitation as full species. But in a large collection these very dissimilar shells are connected by a complete chain of intermediate forms, so that it seems best to regard the extremes as varieties of the main stock.

The table below gives all the species of Astartidæ here recognized as occurring in the Calvert and Choptank formations, and the zones in which each is known to occur:

	Zones
Astarte cuneiformis	10, 14
Astarte cuneiformis var. parma	10
Astarte cuneiformis var. calvertensis	10
Astarte cuneiformis var. obesa	10
Astarte thomasii	10
Astarte exaltata	10
Astarte thisphila	16, 17
Astarte obruta	(17?), 18, 19

In the Calvert Miocene the Astartes can be grouped rather readily into three main stocks:

Astarte cuneiformis stock
  Elongate, triangular outline
    Flattened beak; heavy umbonal ribs .... typical *A. cuneiformis*
    Flattened beak; heavy umbonal ribs; high in proportion to its length .... *A. cuneiformis* var. *parma*
    Beaks not noticeably flattened; fine ribs extending varying distances over disk .... *A. cuneiformis* var. *calvertensis*
    Inflated form; smooth except for a few ribs on umbo .... *A. cuneiformis* var. *obesa*
Astarte thomasii stock
  Quadrate, moderately inflated form; lunule impressed, concave.
    Fine-ribbed variety
    Broad-ribbed variety } *A. thomasii*
Astarte exaltata stock
    High, triangular; H equal to or greater than L; lunule deeply impressed, strongly concave. *A. exaltata*

Astarte cuneiformis Conrad Plate 6, figs. 1-2, 5-6; Plate 7, figs. 5-6

Astarte cuneiformis Conrad, 1840, Fossils of the Medial Tertiary, p. 42, pl. 20, fig. 9; Dall, 1903, Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1494; Glenn, 1904, Maryland Geol. Survey, Miocene, p. 353, pl. 93, figs. 4-6.

Conrad's original description.—Shell trigonal, much compressed; umbo flat, with distant shallow undulations, and acute little prominent ridges; apex very acute; lunule very profound, with a sharply carinated margin; posterior side produced, cuneiform, acutely rounded at the extremity; cardinal teeth long and rather slender; margin crenulated.

Glenn, 1904.—This shell is quite variable. The undulations near the beak may be either coarse or quite fine and may extend over a good portion of the surface, or they may be almost obsolete. The posterior side may be much produced and acutely rounded, giving the shell a distinctly cuneiform shape; or it may be only very slightly, if at all, produced, when the shell becomes more compact and triangular in outline. This shortening may continue until some specimens approach *A. vicina* in outline. The inner margin may be smooth. The base may be regularly arched or may be emarginate posteriorly.

Astarte cuneiformis and its varieties are the most common and characteristic representatives of the genus in the Calvert formation. With one exception, I have found this group only in zone 10 of the Calvert. Five specimens of rather typical *A. cuneiformis* from zone 14 a short distance south of old Plum Point Wharf constitute this exception. It would not be surprising if further collecting would yield additional specimens from the more fossiliferous beds of the upper Calvert. In the sections given in the Maryland Miocene report Shattuck records *A. cuneiformis* from zone 2 on Lyon's Creek (page lxxxvi), but this has not been verified, and I have not observed any Astartes below zone 10.

The *A. cuneiformis* stock is abundant and extremely variable, and as a result several different species have been named corresponding to the extreme variations.

Astarte parma Dall,[5] (pl. 7, fig. 6) appears to be a high variety of *A. cuneiformis*. The umbonal sculpture "with about five small, fine ribs, close together, followed by three or four very distant, much wider ripples, obsolete towards the ends and ventral margin, with a few irregularly spaced linear concentric sulci beyond" (Dall) is not consistent, and is equally characteristic of *A. cuneiformis*.

Astarte calvertensis Glenn[6] (pl. 6, figs. 5-6) represents the extreme variety in which the ribbing is all fine and evenly spaced, and extends over the entire disk. Series of specimens can be obtained ranging from those with the fine ribbing on the umbo only to those with it extending varying distances until it covers the entire disk. No sharp line can be drawn between the forms with the fine ribbing on the umbo only and those with it on the whole disk. Consequently it seems more appropriate to regard *A. calvertensis* as a variety of *A. cuneiformis* rather than as a distinct species. Aside from the character of fine ribbing these varieties differ from typical *A. cuneiformis* only in being slightly less elongate and less pointed posteriorly.

Astarte cuneiformis var. *obesa* Dall[7] (pl. 6, fig. 1) is "thicker and more convex, with the umbones not flattened and the whole surface perfectly smooth." It carries a very few ribs on the extreme tip of the umbo. This variety can be recognized quite readily.

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[5] Dall, W. H.: Wagner Free Inst. Sci., Trans., vol. 3, pt. 6, 1903, p. 1493, pl. 57, fig. 22.

[6] Glenn, L. C.: Maryland Geol. Survey, Miocene, 1904, p. 352, pl. 94, figs. 3-4.

[7] Dall, W. H.: Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, 1903, p. 1494.

Specimens of *A. cuneiformis* from the north end of the cliffs near Randle Cliff Beach average larger, smoother, more elongate, and more pointed posteriorly than those from farther south near Plum Point, and from the "Old Walls Place" in Charles County. The ribs do not usually extend so far over the disk, but are restricted to the umbones. They are usually few and coarse, not approaching the variety *calvertensis,* but tending more in the direction of the variety *obesa.* The specimen illustrated on plate 7, figure 5 is representative of the forms from zone 10 near Randle Cliff Beach. Only one specimen from this locality showed fine ribbing approaching the variety *calvertensis.* One specimen might be called the variety *parma.*

Some of the Randle Cliff specimens resemble *A. perplana* of the St. Mary's, but the latter is higher in proportion to its length and more trigonal in shape. Also, the beaks are more nearly centrally located, and the ribs on the umbones are heavier and more smoothly rounded.

Astarte cuneiformis

Figured specimens.—Nos. 3936 and 3946, Paleontological Research Institution.

Horizon.—Zones 10, 14, Calvert Miocene.

Localities.—1, 36, 4, 2, 5, 3, 48, 9, 13, 62, 43, 38; 53.

Astarte cuneiformis var. *obesa*

Figured specimen.—No. 3935, Paleontological Research Institution.

Horizon.—Zone 10, Calvert Miocene.

Localities.—1, 36, 2, 48, 9.

Astarte cuneiformis var. *calvertensis*

Figured specimens.—Nos. 3939 and 3940, Paleontological Research Institution.

Horizon.—Zone 10, Calvert Miocene.

Localities.—1, 2, 3, 48, 9.

Astarte cuneiformis var. *parma*

Figured specimen.—No. 3947, Paleontological Research Institution.

Horizon.—Zone 10, Calvert Miocene.

Localities.—1, 2, 3, 48.

Glenn[8] described a new species, *Astarte castrana,* from the Calvert as follows:

> Shell triangular, nearly equilateral, with rounded base; beak acute, turned slightly forward; shell flat or depressed; outer surface with small, shallow concentric grooves near the beak, slightly undulated over the rest of the shell by obscure and irregular growth lines, or in some specimens almost perfectly smooth over this outer part; teeth robust; ligament areas impressed; pallial line distinct; margin smooth or crenulated.
>
> This species is doubtless the ancestor of *Astarte thisphila* from which it may be readily separated by its much smoother surface, much flatter form and thinner shell, as well as by its lacking the flattening or depression near the umbo so characteristic of *thisphila.* It has a less prominent beak, is flatter, less symmetrically rounded, thinner, and much less smooth on the surface than *Astarte obruta.* It is found only at a lower horizon than either of the other two species mentioned above.

So far I have never seen any specimens from the Calvert formation which I could identify, on the basis of this description, as *Astarte castrana.* Some young specimens of *A. thisphila* from zone 17 of the Choptank answer most closely to the above description, but there seems to be no adequate reason for trying to separate these from *Astarte thisphila.*

Astarte thomasii Conrad Plate 7, figs. 1-4

Astarte Thomasii Conrad, 1855, Acad. Nat. Sci. Philadelphia Proc., vol. 7, p. 267; 1866, Am. Jour. Conch., vol. 2, p. 72, pl. 4, fig. 16.

Astarte thomasii Conrad. Glenn, 1904, Maryland Geol. Survey, Miocene, p. 351, pl. 94, figs. 1-2.

Conrad's original description.—Triangular, not ventricose, inequilateral; ribs concentric, robust, recurved; concentric lines more or less marked, minute; towards the posterior end the ribs suddenly become obsolete; extremity truncated, nearly direct, or sloping inwards; inner margin crenulated; lunule large, ovate, acute, deeply excavated.

Locality.—Near Mullica Hill. Prof. Thomas.

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[8] Glenn, L. C.: Maryland Geol. Survey, Miocene, 1904, p. 353, pl. 93, figs. 7-9.

Astarte thomasii represents a considerably less common stock of Astartes than *A. cuneiformis.* It is distinct and can readily be distinguished by its more quadrate outline, inflated form, and lack of flattening on the umbones. Two varieties can be recognized — one with fine, even, well-marked ribs similar to those on *A. cuneiformis* var. *calvertensis,* the other with broader, but less distinct ribs, which do not usually cover the entire disk. The basal part of the shell on the broad-ribbed variety is often smooth, and the entire shell does not reach the size attained by the fine-ribbed variety. This seems to be related to the lithology of the beds in which the species occurs, in that the fine-ribbed variety occurs in the more sandy beds, and the broad-ribbed variety in the more muddy beds.

The specimens figured in the Maryland Miocene report belong to the fine-ribbed variety. An examination of the specimens preserved in the Maryland Geological Survey shows that the exterior view given in figure 1, plate 94, of that report does not portray the ribs clearly. The ribs are more numerous and more rounded than the figure would indicate. An examination of what are probably Conrad's specimens in the Academy of Natural Sciences in Philadelphia indicates the same thing.

There is some intergrading of these two varieties, though it is not so striking as in the case of *A. cuneiformis.* This may well be because the suites of specimens at hand for study are so much smaller in the case of *A. thomasii,* which is a much more rare species. Specimens of *A. thomasii* with fine ribs are similar to *A. calvertensis* in that there is considerable variation in the area of the disk covered by the ribs. Conrad's specimens from New Jersey, in the Academy of Natural Sciences in Philadelphia, have the ribs extending over the entire disk.

The occurrence of *A. thomasii* is rather limited. So far I have found it only in zones 10 at a few localities. It occurs south of old Plum Point Wharf, and at locality 9 in Charles County. South of old Plum Point Wharf the fine-ribbed variety was found in the main mass of the shell bed. For some little distance at this same locality there is a thin shell band at the top of zone 10 which is separated slightly from the rest of the bed. *A. thomasii* is common in this upper thin shell layer, in fact slightly more common than *A. cuneiformis.* It is the broad-ribbed variety which is present here. At the "Old Walls Place" in Charles County, locality 9, *A. thomasii* is again rather common, and both the fine- and broad-ribbed varieties are present, though the former is more common.

Figured specimens.—Nos. 3942-45, Paleontological Research Institution.

Horizon.—Zone 10, Calvert Miocene.

Localities.—3, 48, 9, 43, 38.

Astarte exaltata Conrad Plate 7, figs. 7, 10

Astarte exaltata Conrad, 1841, Acad. Nat. Sci. Philadelphia Proc., vol. 1, p. 29; 1842, Acad. Nat. Sci. Philadelphia, Jour., 1st ser., vol. 8, p. 185; 1845, Fossils of the Medial Tertiary, p. 66, pl. 37, fig. 6; Dall, 1903, Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1489.

Astarte vicina Say. Glenn, 1904, Maryland Geol. Survey, Miocene, p. 350, pl. 93, figs. 10-11.

Conrad's original description.—Obovate, acute, convex; umbo sulcated; apex very prominent; lunule elongated and profound. Height and length equal, 5/8 inch.

Dall, 1903.—A small, high species, with a very much impressed lunule and pointed, concentrically sculptured beaks, the concentric sculpture obsolete towards the ventral margins.

This species and *A. vicina* Say have frequently been confused. Both are rare, and Say's figure of *A. vicina* was poor. Say gave the dimensions of his species as "length nine-tenths of an inch, breadth one inch," but *A. exaltata* never reaches this size. The dimensions of any specimens of *A. exaltata* that I have seen are always less than 3/4 of an inch in either direction.

A study of Conrad's and Say's material as preserved in the Academy of Natural Sciences in Philadelphia indicates that *A. vicina* and *A. thomasii* are more alike than *A. vicina* and *A. exaltata.* Specimens, presumably Conrad's, of *A. vicina* look like forms from the *A. arata* group from Virginia, and I do not feel certain that these specimens even came from Maryland. They look more like specimens from the Yorktown of Virginia.

A. exaltata is usually rare, but at one locality, No. 9, in Charles County, it is common, and slightly more abundant than *A. cuneiformis.* It occurs only in zone 10.

Figured specimen.—No. 3948, Paleontological Research Institution.

Horizon.—Zone 10, Calvert Miocene.

Localities.—2, 3, 48, 9, 43.

In the Choptank formation there are two species of *Astarte*, *A. thisphila* and *A. obruta*. They can usually be separated easily from the Calvert forms and from each other by the characters indicated in the following table:

Short, high, triangular, inflated	
Umbones flattened, heavily ribbed	*A. thisphila* zones 16, 17
Umbones not flattened; surface smooth	*A. obruta* zones 18, 19

A. thisphila is conspicuously flattened in the umbonal region, and bears heavy, angular, concentric ribs, which usually extend 10-15 mm. over the disk. In *A. obruta* the tip of the beak for a distance of not over 5 mm. is flattened and bears a few concentric ribs, but the rest of the shell is moderately inflated and smooth. *A. obruta* is much like an isosceles triangle in outline; *A. thisphila* is less perfectly so.

A. thisphila is much more variable than *A. obruta*. Some varieties resemble *A. obruta* in outline, but can be separated by the heavy ribs and flattening near the beak. A few specimens show such distinct gradations into typical *A. obruta* that the two cannot be separated. Others resemble some varieties of *A. undulata* of the Yorktown, and may have been ancestral to that form, though they are distinct and should not be included with it. Glenn states that *A. thisphila* is usually less convex than *A. undulata*, but this does not hold true for the specimens at hand. The two seem to be about equally convex, though the former is a smaller species.

At many localities the smaller forms of *A. thisphila* are shorter, higher, more inflated, and more conspicuously flattened in the umbonal region than the typical forms. These are so striking that they might almost be given a varietal name, but all gradations into the more typical form are present. This variety is particularly common in zone 17 along the Patuxent River, north and south of

Jones Wharf, and on the Bay shore at localities 27 and 25, north and south of Calvert Beach. This variety is more distinct from *A. obruta* than is the typical *A. thisphila,* and at first, from a comparison of forms from Jones Wharf with the published description, I took the variety to be the typical form. An examination of the types in the Maryland Geological Survey showed that the species was described from the larger, longer and less inflated forms.

A. thisphila occurs in both zones 16 and 17, but it is much more abundant and characteristic in the latter. *A. obruta* occurs in zones 18 and 19, and is more abundant and characteristic in zone 19. It is the only *Astarte* occurring in zone 19. I have never seen a specimen of *A. thisphila* in zone 19, and the Astartes in that zone seem to be quite constant and easily identifiable. In the sections given in the report of the Maryland Geol. Survey *A. thisphila* is reported from zone 19 south of Parker Creek (page lxxxix), and at Flag Pond (page xci), although in the description of the species it is reported to occur only in the lower fossil bed, or zone 17 (pp. 355-356). The reference of this species to zone 19 was probably a mistake. Certainly if *A. thisphila* ever occurs in zone 19 it is not common enough to be considered characteristic.

Glenn reported *A. thisphila* from the Calvert formation at Plum Point, but I have never seen it outside of the lower portion of the Choptank formation. If it does occur in the Calvert, it is very rare.

On the other hand rare specimens of *A. obruta* were collected by the author from zone 17, but these were so few that they do not invalidate the statement that *A. obruta* is characteristic only of zone 19. At one locality north of Scientists' Cliffs, *A. obruta* was found commonly in the clays between zones 17 and 19, that is, in zone 18.

The source of *A. thisphila* is not clear, and it seems to be more closely related to *A. distans* from the New Jersey Kirkwood formation and to *A. floridana* from the Florida Choctawhatchee than to any of the forms in the Calvert Miocene of Maryland.

Astarte thisphila Glenn Plate 8, figs. 1, 4

Astarte thisphila Glenn, 1904, Maryland Geol. Survey, Miocene, p. 355, pl. 94, figs. 7-9.

Glenn's original description.—Shell triangular; moderately thick, convex, but depressed or flattened near the beak; angular undulations on the beak prominent, becoming broader farther from the beak and extending well toward, or in some cases entirely to, the basal margin; tip of beak curved forward, producing a convex curve or shoulder on the dorsal margin just posterior to the apex; anterior margin regularly rounded; basal margin rounded anteriorly, straight or slightly emarginate posteriorly; posterior extremity above the line of the base and obtusely rounded; interior smooth except in quite young specimens, when it is sometimes slightly undulated; teeth strong . . .

It differs from the *A. obruta* by having a less symmetrically curved surface and outline, by being strongly undulated and by the characteristic convex curve or shoulder just posterior to the tip of the beak . . .

Figured specimens.—Nos. 3950 and 3952, Paleontological Research Institution.

Horizon.—Zone 16, 17, Choptank Miocene.

Localities.—23; 57, 27, 25, 44, 56, 34, 7, 6, 59.

Astarte obruta Conrad Plate 8, fig. 5

Astarte obruta Conrad, 1834, Acad. Nat. Sci. Philadelphia, Jour., 1st ser., vol. 7, p. 150; 1840, Fossils of the Medial Tertiary, p. 43, pl. 21, fig. 2; Glenn, 1904, Maryland Geol. Survey, Miocene, p. 354, pl. 94, figs. 5-6.

Conrad's original description.—Shell triangular, convex, smooth, with a few obsolete undulations; beaks prominent, sulcated, margin crenulated . . .

Allied to *A. undulata* Say, but is more convex and not profoundly undulated; the umbo is not flattened.

Glenn, 1904.—Shell nearly equilateral, moderately thick; the sulcations on the beak usually not prominent and extending but a very short distance from the tip of the beak; the rest of the gently convex surface smooth except for a few broad, almost obsolete, undulations; surface occasionally crossed from beak to base by exceedingly faint, slightly impressed, radial lines; beak projecting, acute, with its very tip curved somewhat forward.

The gently rounded outline, and moderately convex, almost smooth surface serve to distinguish this species from any other . . .

Figured specimen.—No. 3953, Paleontological Research Institution.

Horizons.—Zone 17 (rare); zones 18, 19, Choptank Miocene.

Localities.—6, 59; 49; 33, 15, 55, 51.

Family CRASSATELLIDÆ

Genus EUCRASSATELLA Iredale

Three species of *Eucrassatella* are present in the Calvert and Choptank formations of the Maryland Miocene. They are closely related species, but they are sufficiently distinct in characteristics and distribution to serve as horizon markers. *E. melina* is characteristic of zone 10 of the Calvert, but also occurs in zone 14. *E. turgidula* occurs sparsely in zone 16 of the Choptank, abundantly in zone 17, and in zone 18 at one locality. *E. marylandica* is common and characteristic in zone 19 of the Choptank, and occurs only in zone 19 so far as I am aware. One specimen of *Eucrassatella* was reported by Mansfield from the St. Mary's formation of the St. Mary's River, and I collected one specimen from the St. Mary's at Langley's Bluff.

A few of the distinguishing characteristics of the three species are summarized in the following table:

Beaks conspicuously flattened.	
Umbonal ribs extend less than 8 mm. from beak; about 10 in number	*E. melina* zones 10, 14
Umbonal ribs extend 10-15 mm. from beak; about 10 in number	*E. turgidula* zones 16-18
Beaks rounded, incurved	
Umbonal ribs extend 5 mm. or less from beak; 4-5 in number, but usually eroded	*E. marylandica* zone 19

The original descriptions and some later characterizations of the species are quoted below for reference. For the purpose of the present discussion it seems best to consider all the species together and to treat them as a group, rather than under the headings of the individual species.

There appear to be no consistent differences in suites of specimens from different localities, as was the case with some other forms, such as the Pectens. The chief distinctions which can be made among the three species relate to the following characters — shape, thickness, and convexity of the shell; flattening of the umbo; umbonal ribs.

E. marylandica can usually be separated from the other two species by its rounded beak. The umbones of *E. melina* and *E. turgidula* are conspicuously flattened and bear heavy ribs. In *E. marylandica* there is only a very slightly flattening which does not extend for more than 5 mm. and which is commonly obscured by erosion of the beaks. The beaks are smooth except for a few fine concentric ribs which are present only in well-preserved specimens.

The umbonal ribs in *E. melina* are of the same general character as in *E. turgidula*. The earliest ones are fine, the later ones coarser. In *E. turgidula* they extend slightly further over the disk and become coarser than in *E. melina*. In both species they die out anteriorly, and are absent posterior to the umbonal ridge. They are heaviest just anterior to the umbonal ridge.

E. melina is thinner-shelled and more evenly convex over the entire surface than the other two species. *E. turgidula* and *E. marylandica* are heavier, more strongly convex, and more pointed posteriorly than *E. melina*. The average specimen of *E. melina* is more square posteriorly. The shell substance is thicker in both *E. turgidula* and *E. marylandica* than in *E. melina*. Specimens of *E. turgidula* which are not full grown are less thickened.

The outline of *E. marylandica* is much like that of *E. turgidula,* but the posterior dorsal margin is more concave, and consequently the posterior part of the shell appears to be longer, narrower, and more pointed. *E. turgidula,* in turn, is narrower and more pointed posteriorly than *E. melina*. The posterior dorsal margin is slightly concave, but less so than in *E. marylandica,* and more so than in *E. melina*. In young specimens the posterior dorsal margin is straight or slightly convex, and the outline of the shell is more like that of *E. melina*. Young specimens of the two species are somewhat difficult to differentiate, but in *E. turgidula* the umbonal ribs are heavier and extend a little further over the disk.

Of the three species, *E. melina* is the most compressed. *E. turgidula* and *E. marylandica* are about equally convex, but both are more convex than *E. melina*. *E. marylandica* appears more convex because the beak is more rounded and more strongly incurved. In *E. turgidula* the greatest convexity is sometimes centered at a point just posterior to the center of the shell, giving the entire shell a slightly twisted aspect.

The truncated, posterior, dorsal slope is most flattened in *E. melina*. In both *E. turgidula* and *E. marylandica* it is narrower and more rounded, and bears a secondary ridge proceeding from the border of the escutcheon to the posterior dorsal angle. It is separated from the principal surface of the shell by a sharper angle than in the case of *E. melina.*

In Glenn's description of *E. melina* he noted that the species is "somewhat more produced posteriorly and hence is proportionally narrower along the obliquely truncated posterior margin than is represented in Conrad's figure." This is true for some of the specimens from zone 10 in Maryland, but there is also considerable variation in the degree of elongation of the posterior part of the shell, and Conrad's figure is typical of some of the shorter forms. Undoubtedly these forms all belong to the same species, for the range of variation is not great enough to enable one to pick out the extremes as separate species even if the intermediate forms were absent .

Glenn's statement (see quotation below) that adult specimens of *E. turgidula* and *E. marylandica* are difficult to separate seems less true of the suites of specimens which the present writer has collected than the fact that *E. melina* and *E. turgidula* are difficult to separate. This difference of opinion might be taken as an indication of the close relationship of all three species. Specimens from zone 14 of the Calvert formation are somewhat difficult to determine, because the preservation of all shells from this bed is poor. They are identified as *E. melina* in this report, although if more perfect specimens were available it is possible that they would be intermediate between *E. melina* and *E. turgidula.*

Forms from zone 18 at locality 49, north of Scientists' Cliffs, are intermediate between *E. turgidula* and *E. marylandica.* All the specimens obtained were somewhat broken, but they resemble *E. marylandica* except for the beaks, which are flattened and ribbed as in *E. turgidula.*

Eucrassatella melina (Conrad) Plate 6, figs. 3-4

Crassatella melina Conrad, 1832, Fossil Shells of the Tertiary Formations of North America, p. 23, pl. 9, fig. 2; 1838, Fossils of the Medial Tertiary, p. 22, pl. 12, fig. 2.

Crassatellites melinus (Conrad). Glenn, 1904, Maryland Geol. Survey, Miocene, p. 346, pl. 92, figs. 1-2.

Conrad's original description.—Ovate, thick, not compressed; anterior margin obtusely rounded; posterior margin oblique and angular; dorsal margin nearly straight; concentric lines coarse; umbonial slope subangular and scarcely curved; beaks with concentric grooves; inner margin entire.

Locality. Cumberland Co., N. J. Upper Tertiary.

This shell is intermediate to *C. undulata* and *Marylandica,* but is perfectly distinct from both . . . .

Glenn, 1904.—This species, as found in Maryland, is more properly described as subovate, convex-depressed, and rather thin except in old specimens, which are somewhat thicker and more convex. It is somewhat more produced posteriorly and hence is proportionally narrower along the oblique truncated posterior margin than is represented in Conrad's figure. The dorsal slope has regular, well marked, angular, concentric undulations near the beak that become obsolete during later stages of growth; posterior and dorsal slopes separated by a distinctly angular line; posterior slope somewhat flattened; posterior dorsal margin but slightly concave; hinge area rather narrow, not massive; muscular impressions and pallial margin very distinct.

Figured specimens.—Nos. 3937 and 3938, Paleontological Research Institution.

Horizons.—Zones 10, 14, Calvert Miocene.

Localities.—1, 36, 4, 2, 5, 3, 48, 9, 38; 45.

Eucrassatella turgidula (Conrad) Plate 6, fig. 7; Plate 7, figs. 8-9

Crassatella turgidula Conrad, 1843, Acad. Nat. Sci. Philadelphia Proc., vol. 1, p. 307; 1845, Fossils of the Medial Tertiary, p. 69, pl. 39, fig. 7.

Crassatellites turgidulus (Conrad). Glenn, 1904, Maryland, Geol. Survey, Miocene, p. 348, pl. 92, figs. 3-5.

Conrad's original description.—Oblong-ovate, slightly ventricose; surface with coarse lines of growth, and concentric undulations obsolete except on the umbones, where they are strongly marked and wide; beaks submedial; umbones flattened; anterior dorsal margin straight; posterior extremity truncated and nearly direct, more oblique in young shells; basal margin swelling a little anteriorly, posteriorly straight to the extremity which is obliquely angulated.

Locality. Calvert Co., Md.

Allied to C. Marylandica, but has less prominent, more flattened umbones, which are widely and profoundly undulated. It is, also, more ventricose, and has a more regularly arched basal margin. Young shells of the two species are widely unlike each other.

Glenn, 1904.— Shell thick, convex, and not strongly produced posteriorly; umbo not prominently elevated; posterior dorsal margin slightly concave or nearly straight; hinge area broad; teeth robust; muscular impressions deep; pallial line distinct.

The young are long-ovate in outline, thin and flat; surface with very prominent, regular, angular, concentric undulations on the umbonal slope and extending over a large portion of the entire surface of the shell; posterior dorsal margin straight or convex.

This species is likely to be confused with *C. marylandicus,* but may be separated in the adult stage by having a less prominent, broader, and more flattened umbo and a more profoundly and widely undulated umbonal slope, by being less produced posteriorly and by having a much less concave posterior dorsal margin. The young of the two species are quite distinct and need never be confused with each other.

Figured specimens.—Nos. 3941 and 3949, Paleontological Research Institution.

Horizons.—Zones 16-18, Choptank Miocene.

Localities.—23, 24; 7, 6, 10, 21, 59, 27, 25, 44, 57, 56; 49.

Eucrassatella marylandica (Conrad) Plate 8, figs. 2-3, 6

Crassatella Marylandica Conrad, 1832, Fossil Shells of the Tertiary Formations of North America, p. 22, pl. 8, fig. 1; 1838, Fossils of the Medial Tertiary, p. 21, pl. 12, fig. 1.

Crassatellites marylandicus (Conrad). Glenn, 1904, Maryland Geol. Survey, Miocene, p. 347, pl. 93, figs. 1-3.

Conrad's original description.—Ovate oblong, thick and ponderous; posterior side narrowed and produced, with the extremity slightly angular or obtusely rounded; umbonial slope subangular; inner margin entire.

Locality. Choptank river, near Easton, Md. Upper Ter.

. . . .

Glenn, 1904.—Shell convex; umbo elevated and prominent; regular concentric undulations on umbonal slope very slightly developed or obsolescent; surface marked by somewhat irregular growth lines; posterior basal margin often slightly emarginate; posterior and dorsal slopes meet in an angular line or ridge; posterior slope crossed by a slightly obtuse ridge extending from the beak to the upper end of the obliquely truncated posterior margin; posterior dorsal margin deeply concave, anterior one straight; hinge area broad; teeth robust; muscular impressions deep; pallial line distinct.

The young are convex, thick and massive also, with prominent beaks and but slightly produced posterior extremity, giving the shells a triangular outline. The regular, concentric undulations on the umbonal slope are small and not profound and are confined to the portion of the surface in the immediate vicinity of the umbo.

This species is likely to be confused in the adult stage with *C. turgidulus*, with which it is doubtless closely related.

Figured specimens.—Nos. 3951 and 3954, Paleontological Research Institution.

Horizon.—Zone 19, Choptank Miocene.

Localities.—33, 55, 15, 51.

Family LUCINIDÆ

Genus SAXOLUCINA Stewart

Subgenus MEGAXINUS Brugnone, 1880 (emend.)

Two species of *Saxolucina* are present in the Maryland Miocene, *S. foremani* and *S. anodonta*. *S. anodonta* appears first in zone 10 of the Calvert formation, and continues throughout the Calvert, Choptank, and St. Mary's. It also occurs in the Yorktown Miocene of Virginia, and in the Pliocene of South Carolina and Florida. *S. foremani* occurs chiefly in zone 10 of the Calvert. Glenn reported it from the Choptank formation at Governor Run, but I have not found it except in zone 10.

Certain facts concerning the distribution of these two species within the Calvert formation are of interest. *S. anodonta* is much more abundant at the north end of the cliffs (near Randle Cliff Beach) than at any other locality in zone 10, and *S. foremani* is rather rare here. Further south *S. anodonta* gradually becomes less abundant, and *S. foremani* more abundant. However, even where *S. foremani* is most abundant, it is never so abundant as *S. anodonta* at the localities where the latter is most common. For example, north of Randle Cliff Beach I collected more than 80 specimens of *S. anodonta,* to three of S. *foremani.* At Plum Point (locality 3) I collected 19 specimens of *S. anodonta* to 40 of *S. foremani.* The first locality south of Randle Cliffs where *S. foremani* is common is number 5, south of Camp Roosevelt. *S. foremani* is more common than *S. anodonta* at the "Old Walls Place," locality 9.

A few variations in the form of *S. anodonta* can be noticed in suites of specimens from different beds and different localities. Specimens from the Choptank are on the average larger than those from either the Calvert or the St. Mary's. They are also slightly flatter in proportion to their size than those from the Calvert. Specimens from zone 17, especially from Jones Wharf, seem to have the growth lines and surface more even and regular than on those from the Calvert formation.

Specimens from any beds may be considerably thickened by the addition of material to the inside of the shell, chiefly in the area enclosed by the pallial line, but this tendency is especially noticeable in specimens from zone 19 of the Choptank. Some forms from zone 19 north of Camp Conoy are thickened in this way until they are almost half an inch thick. This is probably a pathological character. The inside of the shell, principally the area enclosed by the pallial line, is commonly very rotten and tends to break away from the rest of the specimen. The muscle scars show a similar tendency. Often they are represented by holes where the shell substance has broken out.

Specimens from the St. Mary's formation are somewhat intermediate between *S. anodonta* and *S. foremani.* They are smaller than *S. anodonta* from the Choptank, slightly smaller than *S. anodonta* from the Calvert, but larger than *S. foremani.* They are more convex than *S. anodonta,* less so than *S. foremani.* They are less perfectly orbicular and have more clearly developed angles where the dorsal and posterior, posterior and ventral margins meet than in *S. anodonta* from the Calvert and Choptank.

Mansfield[9] mentioned that "The shell of this species (*S. anodonta*) from the Calvert and Choptank formations is larger and thinner than that in the succeeding St. Mary's formation." It is true that they are larger, but they are not consistently thinner. The St. Mary's specimens in my collections are more consistent in thickness than those from the Calvert and Choptank, and many from the latter are thicker than any St. Mary's forms.

Saxolucina (Megaxinus) foremani (Conrad) Plate 11, fig. 5

Lucina Foremani Conrad, 1841, Acad. Nat. Sci. Philadelphia Proc., vol. 1, p. 29; 1842, Acad. Nat. Sci. Philadelphia Jour., 1st ser., vol. 8, p. 184; 1845, Fossils of the Medial Tertiary, p. 71, pl. 40, fig. 4.

Phacoides (*Pseudomiltha*) *foremani* (Conrad). Glenn, 1904, Maryland Geol. Survey, Miocene, p. 336, pl. 90, figs. 1-2.

Saxolucina (*Megaxinus*) *foremani* Say. Chavan, 1938, Jour. conchyliologie, vol. 82, p. 79.

Conrad's original description.—Orbicular, ventricose, moderately thick; surface with irregular shallow grooves, and rather distant prominent striæ, with intermediate, fine, concentric lines; posterior margin subtruncated obliquely outwards; beaks prominent, not central; hinge edentulous. Length 1 1/2 inch.

Glenn, 1904.—It may be distinguished from *P. anodonta* by being smaller and much more convex; as found in Maryland, the interior, prismatic portion of the shell is often badly decayed, while the exterior portion is usually well preserved; it is at times quite thick.

Figured specimen.—No. 3966, Paleontological Research Institution.

Horizon.—Zone 10, Calvert.

Localities.—1, 4, 2, 3, 48, 9.

Saxolucina (Megaxinus) anodonta (Say) Plate 10, fig. 5

Lucina anodonta Say, 1824, Acad. Nat. Sci. Philadelphia Jour., vol. 4, p. 146, pl. 10, fig. 9; Conrad, 1840, Fossils of the Medial Tertiary, p. 39, pl. 20, fig. 4.

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[9] Mansfield, W. C.: *Miocene pelecypods of the Choctawhatchee formation of Florida,* Florida Geol. Survey Bull. 8, 1932, p. 99.

Phacoides (*Pseudomiltha*) *anodonta* (Say). Dall, 1903, Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1378; Glenn, 1904, Maryland Geol. Survey, Miocene, p. 337, pl. 90, figs. 3-4; Mansfield, 1932, Florida Geol. Survey Bull. 8, p. 98, pl. 20, fig. 19.

Saxolucina (*Megaxinus*) *anodonta* Say. Chavan, 1938, Jour. conchyliologie, vol. 82, p. 79.

Say's original description.—Orbicular, slightly transverse, compressed; teeth obsolete.

Shell with elevated wrinkles; orbicular, a little transverse, with a very slight impressed longitudinal line on the anterior margin: anterior and posterior ends equally curved: apices not prominent beyond the general curve of the shell, with a very short deep emargination behind them; teeth obsolete; both the cardinal and lateral ones are generally altogether wanting: lunule short, cordate, profound.

Length from the apices to the base one inch and one-tenth, breadth one inch and one-fifth.

The impressed line on the anterior part of the shell is hardly visible in many specimens, and is sometimes only a very slight undulation, not observable but on close inspection . . .

Figured specimen.—No. 3960, Paleontological Research Institution.

Horizons.—Zone 10, Calvert, zones 17, 19, Choptank.

Localities.—1, 36, 2, 5, 3, 48, 9; 6, 10, 21, 59, 7, 44, 27, 25, 47; 33, 55, 15.

Genus **LUCINOMA** Dall

Lucinoma contractus (Say) Plate 11, fig. 9

Lucina contracta Say, 1824, Acad. Nat. Sci. Philadelphia Jour., 1st ser., vol. 4, p. 145, pl. 10, fig. 8; Conrad, 1840, Fossils of the Medial Tertiary, p. 40, pl. 20, fig. 5.

Phacoides (*Lucinoma*) *contractus* (Say). Glenn, 1904, Maryland Geol. Survey, Miocene, p. 339, pl. 90, figs. 5-6; Mansfield, 1932, Florida Geol. Survey Bull. 8, p. 99, pl. 20, fig. 23.

Say's original description.—Shell convex, suborbicular, with numerous concentric, regular, equidistant, elevated, membranaceous striæ, and intermediate smaller transverse lines: umbones not very prominent: apices proximate, nearly central: anterior hinge margin rectilinear, to an obtuse angle near the middle of the anterior margin: anterior submargin with a very slightly impressed line: posterior margin rounded: cardinal teeth one in the left valve, and two in the right, the posterior one of which is subbifid at tip: lateral teeth none: within obsoletely striated towards the margin: posterior muscular impression perfectly rectilinear, elongated, and oblique.

Length one inch and nine-tenths, breadth two inches and one-tenth.

This species was reported by Shattuck as common and characteristic of zones 1-3 of the lower Calvert. The lowest stratigraphic horizon at which I have found it is zone 14 of the upper Calvert. It is very common in zone 16 of the Choptank just north and south of Calvert Beach and in fact is the most common single species here. It occurs in its living position with the plane between the valves vertical. It is the most conspicuous example in all the Maryland Miocene of a fossil being preserved in its living position.

Locality 27, north of Calvert Beach is the only locality where this form is abundant in zone 17. It was found in zone 17 at two other localities, number 44 just north of Long Beach, and number 6 south of Jones Wharf, but only a few specimens were collected at each place. One double-valved specimen was found in the St. Mary's formation at Little Cove Point. For the most part it seems to be true that this species is most common in beds other than the main shell layers. In beds where the other fossils are most abundant this one is absent or present only in very small numbers. The only exception to this is locality 27, north of Jones Wharf. It is noteworthy that this is the same locality at which the species is most abundant in zone 16.

Specimens of *L. contractus* from the Florida Miocene are larger and more nearly circular than the Maryland specimens.

Figured specimen.—No. 3970, Paleontological Research Institution.

Horizons.—Zone 14, Calvert; zones 16, 17, Choptank.

Localities.—26, 45; 23, 24; 27, 44, 6.

Family **ISOCARDIIDÆ**

Genus **ISOCARDIA** Lamarck

Four, and possibly five, species of *Isocardia* are present in the Calvert and Choptank formations of Maryland. Some of their characters, and their distribution are indicated in the following table:

Length greater than height
  Shell large, inflated, with a pronounced umbonal ridge.
    Moderately rounded, ovate .... *I. fraterna* var. *marylandica*, n. var.
      Zones 14-17
    More elongate and pointed posteriorly .... *I. ignolea*
      Zone 14
  Shell small, not greatly inflated; umbonal ridge not prominent .... *Isocardia* sp.
      "Zone 5"

Length approximately equal to height
  Much inflated, high
    Beak profoundly incurved .... *I. markoëi* Zone 10
    Beak less strongly incurved .... *I. mazlea* Zone 10

All of the Maryland species of *Isocardia* show considerable variation in form. *I. fraterna* var. *marylandica,* n. var. is the most common and the most variable of the Maryland forms. This variety has usually been considered identical with *I. fraterna,* but that name should be restricted to the larger, more circular forms from the Yorktown Miocene of Virginia. A comparison of the Virginia and Maryland forms shows consistent differences which warrant varietal, if not specific, rank.

At the north end of the cliffs along the Bay Shore of Maryland, between Chesapeake Beach and Captain Hubbard's place, there is a thin band of *Isocardia* within zone 5, a short distance above the oyster bed. The Isocardias in this bed are small, averaging about 1½ inches in length, elongate, and usually somewhat crushed. It is rather difficult to obtain perfect specimens from this bed, but those collected are not identical with the forms from the higher beds. Specimens from zone 5 are less pointed posteriorly, the umbonal ridge is less marked and acute, and the dorsal margin parallels the ventral for greater distance than in the Choptank forms. How much of this difference may be due to the different environment in which the forms lived is impossible to say. It accompanies a marked difference in lithology, and it does not seem improbable that the differences might be explained by differences in ecology.

Isocardia ignolea is related to *I. fraterna* var. *marylandica* but is more elongate and pointed posteriorly. It is very similar in shape to young specimens of *I. fraterna marylandica* from zone 17 of the Choptank north of Calvert Beach. The locality and horizon from which the type specimens of *I. ignolea* came is unknown. Glenn gave it as either Plum Point or Little Cove Point, which would mean either the Calvert or St. Mary's formations. Unfortunately the species is rare, and I have not found enough additional specimens to give much information on its distribution. The only specimens in my collection which I could assign to this species are two from zone 14 of the Calvert, at locality 45, south of the mouth of Parker Creek.

Two species which differ more markedly from those mentioned above are *I. markoëi* and *I. mazlea.* They are rare species, and both are limited to zone 10 of the Calvert formation. They can be separated rather readily from *I. fraterna marylandica* and the forms of that group by the fact that they are very short and high, the height and length being about equal. They can be separated from each other by the fact that the beak of *I. markoëi* is considerably more incurved than that of *I. mazlea.* Conrad originally described *I. markoëi* but included figures of both species. His description applies partly to one and partly to the other. Glenn noted that Conrad had included two species, and restricted the name *I. markoëi* to the one with the more strongly incurved beak, and described the other as *I. mazlea.*

Isocardia fraterna var. **marylandica**, n. var. Plate 9, figs. 4-6; Plate 10, figs. 4, 6

= I. [illegible]

Isocardia fraterna Say. Dall, 1900, Wagner Free Inst. Sci., vol. 3, pt. 5, p. 1066 (in part); Glenn, 1904, Maryland Geol. Survey, Miocene, p. 317, pl. 85, figs. 3-4.

Description.—Shell moderately large, inflated, ovate; moderately elongated; often thin-shelled for its size; surface smooth except for growth lines and irregular concentric undulations 5 to 15 mm. wide, probably representing alternate growth and resting stages, and which are sometimes reflected on the inner surface of the shell. Beaks anterior, incurved; umbonal ridge prominent, and making a distinct angle at the posterior ventral margin. Sometimes there is a shallow depressed area just anterior to this ridge; a second, less prominent ridge is often present along the middle of the slope posterior to the umbonal ridge.

This variety differs from typical *I. fraterna* from the higher Miocene beds of Virginia and North Carolina in being smaller and less circular in outline; the umbones are wider and higher; there is often a depressed band extending from the beaks to the posterior-ventral margin, and the posterior end is bluntly pointed. The Virginia forms differ from the variety in their larger size, more rotund and circular outline, lack of the depressed band just in front of the umbonal ridge, and heavier hinge. Say figured and described as *I. fraterna* one of these larger, more circular shells. Hence the designation of *I. fraterna, s. s.* must be restricted to the Virginia shells closest to Say's figure and description.

Considerable variation is shown by the Maryland forms. As noted by Dall, young specimens tend to be more elongate than adults. Some resemble *I. ignolea,* particularly in suites of specimens from zone 17 of the Choptank north of Calvert Beach. Maryland specimens commonly have a pronounced ridge separating the dorsal and posterior slopes. This ridge makes an angle at the margin. The angle is usually more pronounced than is indicated by figure 4, plate 85, of the Maryland Geol. Survey report. Some specimens are much more rounded in outline and inflated, resembling Conrad's drawing (1838) of the Virginia form, while others are flatter and more elongate. Three specimens from zone 16 of the Choptank, north of Calvert Beach, resemble Virginia forms, and are more rounded, inflated, and the umbonal ridge is inconspicuous.

Another variation is represented by more quadrate forms in which the posterior is more square than pointed. Some specimens from zone 14, north of Governor Run are of this type. The only three specimens of *Isocardia* which I have collected from the St. Mary's formation (from St. Mary's River) and a fourth one in the U. S. National Museum from the same locality belong to this variation. These St. Mary's specimens are slightly thinner-shelled than typical forms from other horizons and localities. They possess concentric undulations 10-15 mm. broad, which are reflected on the inner surface of the shell. Finer concentric growth lines are superimposed on these broad undulations. Broad undulations of this type are not uncommon on specimens from other localities, but they are more pronounced, more regular, and more strongly reflected on the inner shell surface of these St. Mary's specimens.

Isocardias are on the whole quite rare in the St. Mary's. The four specimens noted above are the only ones I have ever seen in that formation.

At the present time I cannot state definitely whether *I. fraterna marylandica* occurs in zone 10 of the Calvert. My suites of specimens from zone 10 are small and consist chiefly of *I. markoëi* and *I. mazlea.* A few specimens may represent especially short forms of *I. fraterna marylandica,* but in the absence of a larger series of specimens I cannot separate them positively from *I. mazlea.*

Types.—Holotype, No. 3956; paratypes, No. 3959, 3961; figured specimen 3957, Paleontological Research Institution.

Horizons.—Zone 14, Calvert Miocene; zones 16, 17, Choptank Miocene.

Localities.—54, 53, 45, 26; 23, 24; 27, 25, 44, 34, 47, 57, 7, 6, 59.

Isocardia ignolea Glenn

Isocardia ignolea Glenn, 1904, Maryland Geol. Survey, Miocene, p. 318, pl. 85, figs. 1-2.

Glenn's original description.—Shell oval, moderately elevated anteriorly, gently depressed posteriorly; beak depressed, moderately incurved; surface of shell with numerous gentle, somewhat irregular, close-set, concentric undulations most prominent on the marginal two-thirds of the surface; meeting of posterior and umbonal slopes marked by a ridge, of posterior and basal margins by an angle; posterior margin bluntly rounded; a cardinal and a posterior lateral tooth in left valve, two cardinals in right valve; ligament area curved, ridged, and grooved; interior smooth; muscle impressions and pallial margin distinct.

This species is characterized chiefly by its elongate shape. The type specimens were reported as coming from Cove Point or Plum Point, which would mean that they were St. Mary's or Calvert in age. The only specimens in my collection which I could assign to this species are two from zone 14 of the Calvert formation from a short distance south of the mouth of Parker Creek.

Some young specimens of *I. fraterna marylandica* from zone 17 north of Calvert Beach closely resemble this species in outline. The type specimens of *I. ignolea* appear to be quite distinct from the average *I. fraterna marylandica.* The most inflated part of the shell is just anterior to the center, giving a slightly twisted appearance to the shell. A slightly depressed area runs just anterior to the umbonal ridge. The posterior end is rather pointed.

Horizon.—Zone 14, Calvert Miocene.

Locality.—45.

Isocardia markoëi Conrad (emend.) Plate 10, figs. 1-3

Isocardia Markoëi Conrad, 1842, Proc. Nat. Inst., Bull. 2, p. 193, pl. 2, fig. 1 (right hand figures only and diagnosis in part); 1845, Fossils of the Medial Tertiary, p. 70, pl. 40, fig. 2 (right hand figures only and diagnosis in part); Glenn, 1904, Maryland Geol. Survey, Miocene, p. 316, pl. 84, figs. 2-3.

Conrad's original description.—Suborbicular: length and height nearly equal; inflated; umbo very prominent, and the beaks profoundly incurved; posterior margin direct, arched above, nearly straight below, and obtusely angulated at its junction with the base; base regularly, not profoundly arched; posterior slope slightly sinuous.

Glenn, 1904.—Conrad has figured in each case cited above two forms that on comparison of a number of specimens show constant differences, and his description applies partly to one and partly to the other. It becomes necessary, therefore, to restrict his name, and as the remarkable elevation and profound incurvature of the beaks seem to have been perhaps the most prominent characteristics in his mind—just as they produce the more striking of the two forms—the name *I. markoëi* will here be used to designate the species with highly elevated, narrow, prolonged, profoundly incurved beaks, a feature well represented in the right hand drawing of each of his figures. It is about as high as long; posterior margin quite or almost entirely arched; dorsal slope crossed by two or three broad, deep, concentric undulations marking resting stages during growth.

Figured specimen.—No. 3958, Paleontological Research Institution.

Horizon.—Zone 10, Calvert Miocene.

Localities.—3, 9.

Isocardia mazlea Glenn Plate 9, figs. 1-3

Isocardia Markoëi Conrad, 1842, Proc. Nat. Inst., Bull. 2, p. 193, pl. 2, fig. 1 (left hand drawing only and diagnosis in part); 1845, Fossils of the Medial Tertiary, p. 70, pl. 40, fig. 2 (left hand drawing only and diagnosis in part).

Isocardia mazlea Glenn, 1904, Maryland Geol. Survey, Miocene, p. 317, pl. 84, figs. 4-5.

Glenn's original description.—Shell rounded, inflated; length greater than height; umbo elevated, broad, short, only moderately incurved, not strongly projecting; dorsal slope crossed by several shallow and at times indistinct concentric undulations; posterior margin curved above, straight below and meeting the base at an obtuse angle to which there extends a flattened ridge which is bordered on the posterior slope by a broad, gently depressed or grooved area. See also remarks under *I. markoëi*.

Figured specimen.—No. 3955, Paleontological Research Institution.

Horizon.—Zone 10, Calvert Miocene.

Localities.—2, 3, 9.

Family VENERIDÆ

Subfamily VENERINÆ

Genus ANTIGONA Schumacher

Section ARTENA Conrad

Antigona (Antigona) staminea (Conrad) Plate 11, figs. 6-8

Cytherea staminea Conrad, 1839, Fossils of the Medial Tertiary, back cover of No. 1, pl. 21, fig. 1.

Cytherea (*Antigona*) *staminea* Conrad. Glenn, 1904, Maryland Geol. Survey, Miocene, p. 314, pl. 76, figs. 6-8.

Antigona (*Antigona*) *staminea* (Conrad). Palmer, 1927-1929, Palæontographica Americana, vol. 1, No. 5, p. 329, pl. 27, figs. 2, 4-5, 9-11, 14.

Conrad's original description.—Shell subtriangular, thick, with about ten very prominent acute slightly reflected concentric ribs, with an intermediate carina, and crowded minute lamellar striæ; anterior tooth very small; margin crenulated. Length 1 inch. Locality, Calvert County, Md.

Glenn, 1904.—Form compact, rounded, triangular; valves convex; beak not prominent; ribs perpendicular to the surface and at times as many as sixteen; posterior edge of dorsal slope often marked by a slight ridge causing a slight posterior basal emargination; cardinal teeth three in each valve; anterior lateral tooth in left valve very small and rounded and fitting into a correspondingly small socket in right valve; muscular impressions subequal; pallial sinus a mere notch.

This species is very common and abundant in zone 10 of the Calvert formation. It also occurs in zone 12, south of the mouth of Parker Creek, but was not collected from that zone. As the distribution chart indicates, it was present at every locality but one, at which collections were made from zone 10. That one was locality 13 at Hollin Cliff, and its absence there can be attributed to the extremely small size of the collection made there, and the poor condition of the specimens. The collection from this place was obtained by digging in the cliffs with a spade, and it consisted of only a few, poorly preserved specimens. Under these circumstances *A. staminea* could very easily have been overlooked.

The young of this species are more elongate in proportion to their height than the adults. A few specimens were more pointed posteriorly than the average, but there was no apparent relationship between this character and the geographic distribution.

The intermediate carina mentioned by Conrad is not a common nor a prominent feature. The ribs are usually more numerous than Conrad's number would indicate, as many as sixteen being found on many specimens.

Suites of specimens from different localities do not show any consistent differences, except in a few forms from the upper thin shell layer of zone 10 between Dares Wharf and Plum Point, (localities 38 and 43). These are slightly larger, less inflated, longer in proportion to their height, and more evenly rounded than typical forms. Only a few specimens were collected from these localities, however, so these statements are based on an examination of less than a dozen specimens.

This species is not known to occur on the St. Mary's River, as stated by Dall.

Figured specimens.—Nos. 3967-69, Paleontological Research Institution.

Horizon.—Zone 10, Calvert Miocene.

Localities.—1, 36, 4, 2, 5, 3, 48, 9, 62, 43, 38.

Genus **CHIONE** Megerle von Mühlfeld

Subgenus **LIROPHORA** Conrad

Three distinct species of *Chione* are present in the Maryland Miocene, and all three have some value as horizon markers. The species and their ranges are as follows:

- Radial sculpture present
  - Concentric laminæ thickened, rounded, irregular, and partially confluent .... *C. latilirata*
Zone 10, Calvert
  - Concentric laminæ thickened, flattened, completely confluent .... *C. parkeria*
Zone 14, Calvert
- Radial sculpture absent
  - Concentric laminæ elevated, sharp or rounded, regular, but distinct .... *C. alveata*
Zone 24?, St. Mary's

Chione latilirata was first described from the Calvert formation of the Calvert Cliffs, Maryland, but it ranges through the Upper Miocene and Pliocene, and is still living from Cape Hatteras, North Carolina, to Rio Grande do Sul, Brazil. In Maryland I have never found it in any beds other than zone 10 of the Calvert formation, although Glenn reported it from the Choptank at Greensboro. In view of its range up to the Recent it is somewhat surprising that it has not been found elsewhere in the Maryland Miocene. However, it certainly is not common in any beds other than zone 10, even should further collecting yield a few specimens from other horizons.

Chione parkeria was described by Glenn from the Calvert formation south of the mouth of Parker Creek, but no information was given regarding its more detailed stratigraphic occurrence. The species occurs in zone 14 of the Calvert formation at this and other localities. It does not occur in zone 10, the main fossil bed of the Calvert formation, at any locality so far as known. It is very common and characteristic of zone 14, and possibly occurs in zone 12. It occurs at almost every locality where zone 14 can be identified, and is frequently associated with *Isocardia fraterna* var. *marylandica* in a light-brown clay. There may be a valid question as to whether the species is actually limited to zone 14, or whether I have been calling every bed which contained *C. parkeria* zone 14. At any rate, the species is definitely limited to the upper part of the Calvert formation,—to the beds between zones 12 and 15, inclusive.

Chione alveata appears to be limited in Maryland to the St. Mary's Miocene of the St. Mary's River, and does not occur at any other Maryland localities of the St. Mary's formation.

Chione latilirata (Conrad) Plate 11, figs. 3-4; Plate 12, figs. 1-3

Venus latilirata Conrad, 1841, Acad. Nat. Sci. Philadelphia Proc., vol. 1, p. 28; 1845, Fossils of the Medial Tertiary, p. 68, pl. 38, fig. 3.
Chione (*Lirophora*) *latilirata* (Conrad). Dall, 1903, Wagner Free Inst. Sci. Trans., vol. 3, pt. 6, p. 1298 (not pl. 42, fig. 3).
Chione latilirata (Conrad). Glenn, 1904, Maryland Geol. Survey, Miocene, p. 309, pl. 77, figs. 3-4, 6 (not fig. 5).
Chione (*Lirophora*) *latilirata* (Conrad). Palmer, 1927-1929, Palæontographica Americana, vol. 1, No. 5, pp. 387-388, pl. 41, figs. 12, 12a, 13, 33.

Conrad's original description.—Trigonal, convex, depressed, ribs concentric, about 5 or 6 in number, flattened, reflected, irregular, one of them generally very wide; ribs irregularly sulcated on the posterior slope; inner margin finely crenulated. Smaller than *V. alveata*, and with broader, less prominent ribs, which do not diminish in size on the posterior margin.

This species is quite variable as it occurs in Maryland. Specimens are usually small, though this is partly due to the fact that they are not well preserved, but are soft, and the larger ones break up in collecting. The largest ones I have collected measure about 22 mm. long by 18 mm. high, but forms 17 by 14 mm., or smaller, are much more common.

There is considerable variation in the number and breadth of the ribs, the degree to which they are reflected toward the beak and flattened against the disk, and in the closeness of spacing of these ribs.

There are commonly five or six major ribs which are variable in size, and may or may not be well plastered to the disk. In addition there are finer ribs on the umbo, which are more numerous, and may number as many as six or more, before the broader, more prominent ribs start.

Fine, radial, impressed lines appear on the ventral side of each rib in well-preserved specimens. There are no apparent differences between forms from different localities, but the species is much more abundant at the north end of the cliffs near Randle Cliff Beach than further south in the vicinity of Plum Point.

Figured specimens.—Nos. 3964, 3965, 3971-73, Paleontological Research Institution.

Horizon.—Zone 10, Calvert Miocene.

Localities.—1, 36, 5, 2, 3, 43, 38, 9.

Chione parkeria Glenn Plate 11, figs. 1-2

Chione parkeria Glenn, 1904, Maryland Geol. Survey, Miocene, p. 310, pl. 76, figs. 9-11.
Chione (*Lirophora*) *parkeria* Glenn. Palmer, 1927-1929, Palæontographica Americana, vol. 1, No. 5, p. 379, pl. 41, figs. 10, 22, 28.

Glenn's original description.—Shell triangular, depressed, posteriorly somewhat cuneiform, anteriorly rounded; beaks projecting, acute, approximate; lunule distinct, cordate; base posteriorly emarginate; dorsal surface with about five to eight concentric ribs so perfectly flattened and closely appressed to the valve and each other as to become almost obsolete and be marked only by faint undulations and fine concentric impressed or laminated lines; ribs crossed from beak to base by numerous distinct, regular, radiating lines; cardinal teeth three in each valve; laterals none; muscle impressions deep; pallial sinus a slight notch; margin minutely crenulated. This species seems to be closely related to *C. ulocyma* Dall.

This species is larger, more pointed and more emarginate posteriorly than *C. latilirata.* The ribs are so well flattened back against the disk that they are scarcely separable. The surface is usually decorticated, but when present it is covered by fine radial, impressed lines, which are more prominent and more widely spaced than those in *C. latilirata.* There are no apparent differences between forms from different localities.

Figured specimens.—Nos. 3962, 3963, Paleontological Research Institution.

Horizon.—Zone 14, Calvert Miocene.

Localities.—54, 53, 46, 63, 45.

Family **CORBULIDÆ**

Genus **CORBULA** (Brugière) Lamarck

The genus, *Corbula,* is represented in the Maryland Miocene by three subgenera, including four species. The species are all so distinct that they should not be confused. The species and the zones in which they occur are indicated in the following table:

Shell large, height 15-30 mm.	*C.* (*Bicorbula*) *idonea* Zones 10, 14, 17, 18, 19.
Shell small, height less than 15 mm.	
Shell elevated, height approx. equal to length	
Concentric ribs numerous and regular	*C.* (*Corbula*) *elevata* Zones 5-10.
Shell not elevated; length greater than height; length 10 mm. or less	
Sculpture fine and uniform	*C.* (*Caryocorbula*) *cuneata* Zones 10, 17, 19?
Sculpture irregular and coarse	*C.* (*Caryocorbula*) *inæqualis* Zones 10, 16, 17, 19, 24.

Only one of these species, *C. elevata,* has an especially restricted range. It is abundant in zones 5 through 10, but never occurs above the top of zone 10. It was on the basis of the relative abundance of this species that Shattuck differentiated zones 5-9.

The other three species of *Corbula* all appear for the first time in zone 10, and are present in the more fossiliferous beds of both the Calvert and Choptank formations. With the exception of a single, small, worn specimen from Langley's Bluff, Maryland, *C. idonea* was not found in the St. Mary's formation. *C. inæqualis* and *C. cuneata* both occur in the St. Mary's and in the Yorktown in Virginia. *C. inæqualis* is common, but *C. cuneata* is always rare wherever it occurs. *C. inæqualis* is the only *Corbula* that is common in the St. Mary's formation.

All of these species of *Corbula* show a strong tendency for the outer layers of the shell substance to peel. One who fails to notice this tendency would be very likely to describe as distinct species the peeled and unpeeled forms, particularly in species like *C. elevata,* which have characteristic ribbing.

Subgenus **BICORBULA** Fischer

Corbula idonea Conrad Plate 12, figs. 10-14

Corbula idonea Conrad, 1833, Am. Jour. Sci., 1st ser., vol. 23, p. 341; 1838, Fossils of the Medial Tertiary, p. 6, pl. 10, fig. 6.

Corbula (*Corbula*) *idonea* Conrad. Glenn, 1904, Maryland Geol. Survey, Miocene, p. 279, pl. 67, figs. 1-3.

Conrad's original description.—Shell subtriangular, convex, thick, obscurely undulated; with a fold on the posterior submargin and the extremity angular; basal margin acute; cardinal tooth very thick and elevated. Length, one inch.

There seem to be no consistent differences in specimens of this species from different beds and localities. The one exception is that forms from the Choptank formation average slightly larger than those from the Calvert. However, this slight difference in size is not sufficient for separating Choptank from Calvert forms, unless one uses, in addition, the unreliable criterion of color.

Young specimens are longer in proportion to their height than adults, and they are more pointed posteriorly. The rostrum is more conspicuous in the young forms. Right valves are more strongly convex and have the beaks more curved than left valves. The posterior dorsal margin of the right valve is concave; that of the left is straight or slightly convex.

The only surface ornamentation consists of irregular growth lines and gentle concentric undulations. On the right valve the growth lines in the umbonal region are fine and regular, resembling those of *C. cuneata.* Some valves when peeled may show two faint, broad, radial ribs which divide the shell into three unequal sections, the anterior of which is the broadest. These ribs do not show well, if at all, on specimens that have not been peeled. They are more common and conspicuous on left than on right valves. Occasional specimens show a finer, more regular, radial structure when peeled, but this is not common. Some old specimens are considerably thickened.

Figured specimens.—Nos. 3977-79, Paleontological Research Institution.

Horizons.—Zones 10, 14, Calvert Miocene; zones 17, 18, 19, Choptank Miocene; zone ?, St. Mary's Miocene (one specimen only).

Localities.—1, 4, 2, 3, 48, 43, 9; 53, 45; 34, 37, 25, 44, 57, 56, 6, 59; 49; 33, 55, 15, 51; 37.

Subgenus CORBULA, s. s.

(or VARICORBULA Grant and Gale, 1931)

Corbula elevata Conrad Plate 12, figs. 4-9

Corbula elevata Conrad, 1838, Fossils of the Medial Tertiary, p. 7, pl. 4, fig. 3; Whitfield, 1894, U. S. Geol. Survey Mon. 24, p. 86, pl. 15, figs. 15-19; Glenn, 1904, Maryland Geol. Survey, Miocene, p. 280, pl. 67, figs. 4-5.

Conrad's original description.—Shell triangular, equilateral, height greater than the length; inferior valve ventricose, with regular numerous concentric impressed lines, which disappear on the posterior slope; umbo profoundly elevated; posterior slope with an obtuse furrow descending from the beak; extremity narrowed, slightly emarginate.

Whitfield, 1894.—The form is triangularly ovate in outline, slightly inequilateral, and much inflated, both valves being quite ventricose; the beaks are large and very gibbous, that of the deeper valve much the largest. Umbonal ridge distinct in each valve, but not strongly marked. Surface of the valves variable in their markings, usually with impressed concentric lines, but sometimes developing concentric ridges more or less rounded, but indistinct on the umbonal slope . . . In the interior the ligamental pit of the larger valve is very large and deep, excavating the inner face of the beak in most instances. The tooth is also very large and strong.

Whitfield's drawings show forms a little higher in proportion to their length than any I have seen.

One rather important characteristic which has apparently gone unnoticed is that the heavy concentric ribs are confined to the right valves and do not appear on the left valves. The left valves are usually peeled, but when the outer shell layer is still present it has only rather fine, irregular lines which could scarcely be regarded as anything more than growth lines.

The left valves of *C. elevata* are rather difficult to separate from the young of *C. idonea.* The latter are slightly longer in proportion to their height, less inflated, and more pointed posteriorly. The basal margin of *C. idonea* is reflected upward more at the posterior end. In right valves of *C. elevata* the socket and resilial pit make a sharp inverted V, offset from the dorsal margin, while in young *C. idonea* of similar size the V is absent and the dorsal margin is more evenly rounded. The resilial pit of the latter is more inclined to the plane between the valves. *C. idonea* is less perfectly equilateral than *C. elevata.*

Figured specimens.—Nos. 3974-76, Paleontological Research Institution.

Horizons.—Zones 5-10, Calvert Miocene.

Localities.—41, 40a, 52, 39; 1, 14, 35, 36, 5, 2, 3, 11, 28, 48, 9, 13, 43.

Corbula cuneata Say

Corbula cuneata Say, 1824, Acad. Nat. Sci. Philadelphia, Jour. 1st ser., vol. 4, p. 152, pl. 13, fig. 3; Conrad, 1838, Fossils of the Medial Tertiary, p. 5, pl. 3, fig. 3 (right hand fig.).

Corbula (*Cuneocorbula*) *cuneata* Say. Dall, 1898, Wagner Free Inst. Sci., Trans., vol. 3, pt. 4, p. 854; Glenn, 1904, Maryland Geol. Survey, Miocene, p. 282, pl. 67 figs. 15-19.

Say's original description.—Shell transversely ovate-trigonal, acutely angulated or somewhat rostrated before, and depressed on the anterior slope, which is separated from the disk by a subacute line: surface of both valves similarly striate with equal, elevated, equidistant lines, forming grooves between them; the striae on the smaller valve are rather more distant: umbones not prominent.

Length of the larger valve hardly more than the fourth of an inch, breadth more than two-fifths of an inch.

This species is much too rare to be of stratigraphic value. Glenn noted that when it is found at all it is more commonly at the Jones Wharf horizon, or zone 17. It is more elongate and much thinner-shelled than *C. inæqualis*. Glenn observed that its striæ are "much finer and more close set, equal, and equidistant" than in *C. inæqualis*.

Horizons.—Zones 10, Calvert; zones 17, 19?, Choptank Miocene.

Localities.—?1, 2, 3; 27, 25, ?44, 6, 59; ?15.

Subgenus **CARYOCORBULA** Gardner

Corbula inæqualis Say

Corbula inaequale Say, 1824, Acad. Nat. Sci. Philadelphia Jour., 1st ser., vol. 4, p. 153, pl. 13, fig. 2 (fig. at center of page); Conrad, 1838, Fossils of the Medial Tertiary, p. 6, pl. 3, fig. 2, left hand fig. under 3.

Corbula (*Cuneocorbula*) *inaequalis* Say. Dall, 1898, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 853; Glenn, 1904, Maryland Geol. Survey, Miocene, p. 281, pl. 67, figs. 6-14.

Corbula (*Caryocorbula*) *inæqualis* Say. Mansfield, 1932, Florida Geol. Survey Bull. 8, p. 158, pl. 32, figs. 12-13.

Say's original description.—Shell convex, transversely ovate-trigonal, rough, with unequal coarse wrinkles: anterior margin with a very acute but short rostrum at its inferior termination, separated from the disk by an acute line: base rounded and a little contracted near the anterior angle: umbones not prominent.

Length two-fifths, breadth rather more than half an inch.

This species has a different aspect from the preceding (*C. cuneata*); it is longer in proportion to its width, more convex, and the wrinkles, though prominent, are altogether destitute of that equality which distinguishes those of the other shell.

As noted by both Glenn and Mansfield, this species is quite variable in size, thickness, outline of the shell, and the nature and strength of the ornamentation. Glenn observed that:

> Specimens from the Jones Wharf horizon are often more finely striated than those from the Calvert formation, while those from the St. Mary's formation are largest, thickest and have the most rounded base. All agree in having rather coarse, irregular, concentric undulations.

Horizons.—Zone 10, Calvert; zones 16-19, inclusive, Choptank Miocene.

Localities.—1, 36, 4, 2, 3, 43, 48, 62, 13, 9; 23, 24; 44, 27, 25, 6, 59, 7; 49, 33, 55, 15, 51.

STRATIGRAPHIC AND AREAL DISTRIBUTION OF SPECIES

In the following section lists of species are given for each stratigraphic horizon and locality where the writer has made collections. Only species collected by the writer are included. The lists are as complete as possible, except that some of the extremely small and more rare species are omitted. Careful identification of all of these is impossible at present. However, these rare forms have relatively little importance in this study.

The lists are arranged (1) according to stratigraphic horizons, the lowest horizon being given first, and (2) according to localities. The localities, under each zone, are arranged in consecutive order beginning at the north end of the cliffs and working south. Inland localities are listed after those along the Calvert Cliffs. For a more detailed description of the localities than is given at the heading of each list, reference should be made to the locality list.

CALVERT FORMATION

Zones 4, 5-9

From the beginning of the cliffs, south of Chesapeake Beach.
  Locality 19, zone 4, *Ostrea percrassa* bed.
    Ostrea percrassa Conrad
  Same locality, but from zone 5?
    Isocardia cf. I. fraterna var. marylandica, n. var.
    Cardium sp. indet.
  Same locality, zones 5-9?
    Corbula elevata Conrad
North of Randle Cliff Beach
  Locality 42, zone 5? Thin fossil band just above the oyster bed.
    Yoldia sp. indet. (large form)
    Chlamys madisonius (Say)
    Isocardia cf. fraterna var. marylandica, n. var.
    ?Macoma lenis (Conrad)
  Locality 41, zone 6? *Corbula elevata* beds.
    Nucula proxima Say
    Yoldia cf. Y. lævis (Say)
    Atrina harrisii Dall
    Pecten humphreysii Conrad
    Amusium cerinum (Conrad)
    Modiolus ducatellii (Conrad)
    Thracia conradi Couthouy
    Corbula elevata Conrad
    Corbula inæqualis Say
    Vermetus virginicus (Conrad)?

South of Randle Cliff Beach
  Locality 40-b, zone 3? From three feet below the oyster bed.
    Yoldia cf. Y. lævis (Say)
    Cardium sp. indet.
    ?Macoma lenis (Conrad)
  Locality 40, zone 4, *Ostrea percrassa* bed.
    Ostrea percrassa Conrad
    Chlamys madisonius (Say)
    Chlamys madisonius, var. near marylandicus
      Also observed, but not collected:
    Ostrea sp. indet.
    Chlamys madisonius (Say)
    Isocardia, cf. I. fraterna marylandica, n. var.
    Venus sp. indet.
    Panopea, probably P. whitfieldi Dall
    Ecphora sp. indet.
  Locality 40-a, zone 6? *Corbula elevata* beds.
    Pecten humphreysii Conrad
    Corbula elevata Conrad
  Locality 52, zones 5-9
    Atrina harrisii Dall
    Pecten humphreysii Conrad
    Chlamys madisonius (Say)
    Modiolus ducatellii (Conrad)
    Thracia conradi Couthouy
    Corbula elevata Conrad

North of Plum Point Beach
  Locality 39, zone 5 or 6?
    Pecten humphreysii Conrad
    Chlamys madisonius (Say)
    Corbula elevata Conrad

Zone 10

Localities 1, 14, 35, zone 10, north of Randle Cliff Beach.

Pelecypods

Nucula proxima Say
Nucula prunicola Dall
Leda liciata (Conrad)
Glycymeris parilis (Conrad)
Anadara subrostrata (Conrad)
Atrina harrisii Dall
Ostrea percrassa Conrad?
Ostrea sellæformis var. thomasii Glenn?
Pecten humphreysii Conrad
Chlamys madisonius (Say)
Chlamys madisonius (Say), variety
Chlamys coccymelus (Dall)
Amusium cerinum (Conrad)
Modiolus ducatellii (Conrad)
Astarte cuneiformis Conrad
Astarte cuneiformis var. obesa Dall
Astarte cuneiformis var. parma Dall
Astarte cuneiformis var. calvertensis Glenn
Eucrassatella melina (Conrad)
Venericardia granulata Say
Saxolucina (Megaxinus) foremani (Conrad)

Saxolucina (Megaxinus) anodonta (Say)
Phacoides crenulatus (Conrad)
Phacoides trisulcatus (Conrad)
Phacoides prunus Dall?
Cardium leptopleurum Conrad
Cardium craticuloide Conrad
Dosinia acetabulum Conrad
Macrocallista marylandica (Conrad)
Antigona staminea (Conrad)
Chione latilirata (Conrad)
Metis biplicata (Conrad)
Tellina producta Conrad
Tellina declivis Conrad?
Semele carinata (Conrad)
Semele subovata (Say)
Mactra clathrodon Lea
?Paramya subovata (Conrad)
Corbula idonea Conrad
Corbula elevata Conrad
Corbula inæqualis Say
Corbula cuneata Say?
Saxicava arctica (Linné)
Panopea americana Conrad
Panopea whitfieldi Dall

Gastropods
Acteon shilohensis Whitfield
Terebra curvilineata var. whitfieldi Martin
Pleurotoma bellacrenata Conrad
Mangilia parva (Conrad)
Drillia pseudeburnea (Heilprin)
Fulgur sp. indet. (young)
Siphonalia devexa (Conrad)
Nassa peraltoides Martin
Ecphora tricostata Martin
Scala marylandica Martin?
Scala calvertensis Martin
Niso lineata (Conrad)
Odostomia conoidea (Brocchi)?
Turbonilla interrupta (Totten)
Cerithiopsis calvertensis Martin
Vermetus graniferus (Say)
Turritella indenta Conrad
Turritella plebeia Say
Turritella variabilis var. B. Martin
Turritella variabilis var. cumberlandia Conrad
Solarium trilineatum Conrad
Crucibulum costatum (Say)
Calyptræa aperta (Solander)
Xenophora conchyliophora (Born)
Polynices heros (Say)
Polynices hemicryptus (Gabb)
Sinum fragilis (Conrad)

Calliostoma calvertanum Martin
Calliostoma philanthropus (Conrad)
Teinostoma calvertense Martin
Teinostoma liparum (H. C. Lea)
Fissuridea marylandica (Conrad)

Scaphopods

Dentalium attenuatum Say
Dentalium danai Martin (not of Meyer)
Cadulus thallus (Conrad)

Locality 36, zone 10, Calvert, south of Randle Cliff Beach

Pelecypods

Nucula proxima Say
Nucula prunicola Dall
Nucula taphria Dall
Leda liciata (Conrad)
Leda liciata var. amydra Dall
Leda, n. sp.?
Glycymeris parilis (Conrad)
Anadara subrostrata (Conrad)
Atrina harrisii Dall
Pedalion maxillata (Deshayes)
Ostrea sellæformis var. thomasii Glenn
Pecten humphreysii Conrad
Chlamys madisonius (Say)
Chlamys madisonius (Say), variety
Modiolus ducatellii Conrad?
Astarte cuneiformis Conrad
Astarte cuneiformis var. obesa Dall
Crassinella duplinianus (Dall)
Eucrassatella melina (Conrad)
Venericardia granulata Say
Saxolucina (Megaxinus) anodonta (Say)
Phacoides crenulatus (Conrad)
Phacoides trisulcatus var. whitfieldi Dall
Erycina sp. indet.
Cardium leptopleurum Conrad
Cardium craticuloide Conrad
Cardium, n. sp.
Dosinia acetabulum Conrad
Macrocallista marylandica (Conrad)
Antigona staminea (Conrad)
Chione latilirata (Conrad)
Venus rileyi Conrad
Metis biplicata (Conrad)
Tellina producta Conrad
Semele carinata (Conrad)
Mactra clathrodon Lea
Corbula elevata Conrad
Saxicava arctica (Linné)
Panopea whitfieldi Dall

Gastropods

Acteon shilohensis Whitfield
Terebra curvilineata var. whitfieldi Martin
Pleurotoma bellacrenata Conrad

Pleurotoma calvertensis Martin
Surcula marylandica Conrad
Cancellaria sp. indet.
Marginella calvertensis Martin
Fulgur sp. indet.
Siphonalia devexa (Conrad)
Nassa trivittatoides (Whitfield)
Nassa peraltoides Martin
Ecphora tricostata Martin
Scala marylandica Martin
Eulima eborea Conrad
Eulima migrans Conrad
Turbonilla interrupta (Totten)
Cerithiopsis calvertensis Martin?
Vermetus graniferus (Say)
Vermetus virginicus (Conrad)
Turritella indenta Conrad
Turritella plebeia Say
Turritella variabilis var. cumberlandia Conrad
Turritella variabilis var. B Martin
Turritella variabilis var. C Martin
Solarium trilineatum Conrad
Crucibulum costatum (Say)
Crucibulum multilineatum (Conrad)
Calyptræa aperta (Solander)
Polynices heros (Say)
Polynices hemicryptus (Gabb)
Sinum fragilis (Conrad)
Calliostoma aphelium Dall
Calliostoma philanthropus (Conrad)
Teinostoma calvertense Martin
Teinostoma liparum (H. C. Lea)
Teinostoma greensboroënse Martin?

Scaphopods

Dentalium attenuatum Say
Dentalium danai Martin (not Meyer)
Cadulus thallus (Conrad)
Cadulus newtonensis Martin (not Meyer and Aldrich)

Locality 4, zone 10, Calvert, north of Captain Hubbard's.

Pelecypods

Glycymeris parilis (Conrad)
Chlamys madisonius (Say)
Chlamys madisonius bassleri Tucker-Rowland?
Astarte cuneiformis Conrad
Eucrassatella melina (Conrad)
Saxolucina (Megaxinus) foremani (Conrad)
Phacoides crenulatus (Conrad)
Antigona staminea (Conrad)
Corbula idonea Conrad
Corbula inæqualis Say

Gastropods

Ecphora tricostata Martin
Turritella indenta Conrad
Turritella variabilis var. cumberlandia Conrad

Fissuridea marylandica (Conrad)

Locality 5, zone 10, Calvert, from roadcut along main road north of the entrance to Camp Roosevelt.

Pelecypods
Glycymeris parilis (Conrad)
Anadara subrostrata (Conrad)
Pedalion maxillata (Deshayes)
Pecten humphreysii Conrad
Chlamys madisonius (Say)
Astarte cuneiformis Conrad
Eucrassatella melina (Conrad)
Venericardia granulata Say
Saxolucina (Megaxinus) anodonta (Say)
Phacoides crenulatus (Conrad)
Antigona staminea (Conrad)
Chione latilirata (Conrad)
Semele carinata (Conrad)
Corbula elevata Conrad
Saxicava arctica (Linné)

Gastropods
Turritella indenta Conrad
Turritella variabilis var. B Martin

Scaphopods
Dentalium danai Martin (not Meyer)
Cadulus thallus (Conrad)

Locality 2, zone 10, Calvert, south of Camp Roosevelt.

Pelecypods
Nucula proxima Say
Nucula taphria Dall
Leda liciata (Conrad)
Leda liciata var. amydra Dall
Glycymeris parilis (Conrad)
Anadara subrostrata (Conrad)
Pedalion maxillata (Deshayes)
Ostrea sp. indet. (young)
Chlamys madisonius (Say)
Chlamys madisonius bassleri Tucker-Rowland?
Anomia sp. indet.
Modiolus ducatellii (Conrad)
Astarte cuneiformis Conrad
Astarte cuneiformis var. obesa Dall
Astarte cuneiformis var. parma Dall
Astarte cuneiformis var. calvertensis Glenn
Astarte exaltata Conrad
Eucrassatella melina (Conrad)
Venericardia granulata Say
Saxolucina (Megaxinus) foremani (Conrad)
Saxolucina (Megaxinus) anodonta (Say)
Phacoides crenulatus (Conrad)
Phacoides prunus Dall
Erycina speciosa Glenn?
Cardium leptopleurum Conrad?

Isocardia mazlea Glenn
Dosinia acetabulum Conrad
Macrocallista marylandica (Conrad)
Callocardia sp. indet. (young)
Antigona staminea (Conrad)
Chione latilirata (Conrad)
Venus rileyi Conrad
Tellina producta Conrad
Tellina declivis Conrad?
Semele carinata (Conrad)
Mactra clathrodon Lea
Corbula idonea Conrad
Corbula elevata Conrad
Corbula inæqualis Say
Saxicava arctica (Linné)
Panopea whitfieldi Dall

Gastropods
Volvula iota var. patuxentia Martin?
Retusa conulus (Deshayes)
Cylichna calvertensis Martin
Terebra curvilineata var. calvertensis Martin
Surcula marylandica (Conrad)
Mangilia parva (Conrad)
Ecphora tricostata Martin
Scala sayana Dall
Niso lineata (Conrad)
Vermetus virginicus (Conrad)
Turritella plebeia Say
Turritella indenta Conrad
Turritella variabilis var. cumberlandia Conrad
Turritella variabilis var. B Martin
Turritella variabilis var. exaltata Conrad
Tachyrhynchus perlaqueatus (Conrad)
Crucibulum costatum (Say)
Calyptræa aperta (Solander)
Crepidula fornicata (Linné)
Polynices heros (Say)
Polynices hemicryptus (Gabb)
Calliostoma philanthropus (Conrad)
Calliostoma calvertanum Martin
Fissuridea marylandica (Conrad)
Scaphopods
Dentalium attenuatum Say
Dentalium danai Martin (not Meyer)
Cadulus thallus (Conrad)

Localities 3, 11, 28, zone 10, Calvert, south of old Plum Point Wharf.

Pelecypods
Nucula proxima Say
Nucula prunicola Dall
Nucula taphria Dall

Nucula sinaria Dall?
Leda liciata (Conrad)
Leda liciata var. amydra Dall
Leda, n. sp.?
Glycymeris parilis (Conrad)
Anadara subrostrata (Conrad)
Anadara elnia (Glenn)
Ostrea percrassa Conrad
Pecten humphreysii Conrad
Chlamys madisonius (Say)
Chlamys madisonius bassleri Tucker-Rowland?
Amusium cerinum (Conrad)
Anomia sp. indet.
Modiolus ducatellii (Conrad)
Astarte cuneiformis Conrad
Astarte cuneiformis var. parma Dall
Astarte cuneiformis var. calvertensis Glenn
Astarte exaltata Conrad
Astarte thomasii Conrad
Crassinella duplinianus (Dall)
Eucrassatella melina (Conrad)
Venericardia granulata Say
Saxolucina (Megaxinus) foremani (Conrad)
Saxolucina (Megaxinus) anodonta (Say)
Phacoides crenulatus (Conrad)
Phacoides trisulcatus var. whitfieldi Dall
Phacoides prunus Dall
Erycina sp. indet.
?Solecardia cossmanni Dall
Cardium craticuloide Conrad
Cardium laqueatum Conrad
Isocardia markoëi Conrad
Isocardia mazlea Glenn
Dosinia acetabulum Conrad
Macrocallista marylandica (Conrad)
Antigona staminea (Conrad)
Chione latilirata (Conrad)
Venus rileyi Conrad
Tellina producta Conrad
Tellina umbra Dall
Abra marylandica Glenn?
Semele carinata (Conrad)
Ensis ensiformis (Conrad)
Spisula sp. indet.
Mactra clathrodon Lea
Corbula idonea Conrad
Corbula elevata Conrad
Corbula inæqualis Say
Saxicava arctica (Linné)
Panopea whitfieldi Dall
Panopea goldfussii Wagner
Panopea americana Conrad
Gastropods
Pleurotoma bellacrenata Conrad

Surcula marylandica Conrad
Mangilia parva (Conrad)
Cancellaria alternata Conrad
Cancellaria prunicola Martin
Scaphella solitaria (Conrad)
Scaphella typus (Conrad)
Fulgur spiniger (Conrad), variety
Fulgur coronatum Conrad
Fulgur coronatum var. rugosum Conrad
Siphonalia devexa (Conrad)
Ptychosalpinx lienosa Conrad
Columbella calvertensis Martin
Ecphora tricostata Martin
Ecphora quadricostata var. umbilicata (Wagner)
Scala sayana Dall?
Scala marylandica Martin
Scala pachypleura Conrad
Eulima eborea Conrad
Eulima migrans Conrad
Niso lineata (Conrad)
Odostomia conoidea (Brocchi)
Odostomia marylandica Martin
Turbonilla interrupta (Totten)
Cerithiopsis calvertensis Martin?
Vermetus graniferus (Say)?
Vermetus virginicus (Conrad)
Turritella indenta Conrad
Turritella plebeia Say
Turritella plebeia var. A Martin
Turritella plebeia var. B Martin
Turritella variabilis var. cumberlandia Conrad
Turritella variabilis var. exaltata Conrad
Turritella variabilis var. B Martin
Turritella variabilis var. C Martin
Turritella æquistriata Conrad?
Solarium trilineatum Conrad
Rissoa marylandica Martin
Crucibulum costatum (Say)
Calyptræa aperta (Solander)
Crepidula fornicata (Linné)
Crepidula fornicata (Linné), variety
Crepidula plana Say
Xenophora conchyliophora (Born)
Polynices heros (Say)
Polynices hemicryptus (Gabb)
Calliostoma philanthropus (Conrad)
Teinostoma calvertense Martin
Teinostoma liparum (H. C. Lea)
Teinostoma, n. sp.
Fissuridea griscomi (Conrad)
Fissuridea marylandica (Conrad)

Scaphopods
Dentalium danai Martin (not Meyer)
Cadulus thallus (Conrad)

Locality 48 zone 10, Calvert, south of old Plum Point Wharf.
Pelecypods
Nucula prunicola Dall
Nucula taphria Dall
Leda liciata (Conrad)
Leda liciata var. amydra Dall
Glycymeris parilis (Conrad)
Anadara subrostrata (Conrad)
Pecten humphreysii Conrad
Chlamys madisonius (Say)
Anomia sp. indet.
Modiolus ducatellii (Conrad)
Astarte cuneiformis Conrad
Astarte cuneiformis var. obesa Conrad
Astarte cuneiformis var. parma Dall
Astarte cuneiformis var. calvertensis Glenn
Astarte exaltata Conrad
Astarte thomasii Conrad
Eucrassatella melina (Conrad)
Venericardia granulata Say
Saxolucina (Megaxinus) foremani (Conrad)
Saxolucina (Megaxinus) anodonta (Conrad)
Phacoides crenulatus (Conrad)
Phacoides prunus Dall
Cardium laqueatum Conrad
Isocardia mazlea Glenn?
Dosinia acetabulum Conrad
Macrocallista marylandica (Conrad)
Antigona staminea (Conrad)
Chione latilirata (Conrad)
Venus rileyi Conrad
Tellina producta Conrad
Semele carinata (Conrad)
Mactra clathrodon Lea
Corbula idonea Conrad
Corbula elevata Conrad
Corbula inæqualis Say
Saxicava arctica (Linné)

Gastropods
Scaphella solitaria (Conrad)
Scaphella typus (Conrad)
Fulgur coronatum var. rugosum Conrad
Siphonalia devexa (Conrad)
Scala pachypleura Conrad
Niso lineata (Conrad)
Ecphora tricostata Martin
Pyrula harrisii Martin
Vermetus graniferus (Say)
Vermetus virginicus (Conrad)

Turritella plebeia Say
Turritella indenta Conrad
Turritella variabilis var. cumberlandia Conrad
Turritella variabilis var. exaltata Conrad
Turritella variabilis var. A Martin
Crucibulum costatum (Say)
Calyptræa aperta (Solander)
Crepidula plana Say
Xenophora conchyliophora (Born)
Polynices heros (Say)
Fissuridea marylandica (Conrad)

Scaphopods
Dentalium attenuatum Say
Dentalium danai Martin (not Meyer)
Cadulus thallus (Conrad)

Locality 43, upper part of zone 10, Calvert, south of old Plum Point Wharf.

Pelecypods
Nucula taphria Dall
Ostrea sellæformis var. thomasii Glenn?
Chlamys madisonius (Say)
Anomia sp. indet. (young)
Astarte cuneiformis Conrad
Astarte exaltata Conrad
Astarte thomasii Conrad
Eucrassatella melina (Conrad)
Venericardia granulata Say
Cardium sp. indet. (young)
Isocardia fraterna var. marylandica, n. var.
Antigona staminea (Conrad)
Chione latilirata (Conrad)
Corbula idonea Conrad
Corbula inæqualis Say

Gastropods
Scala expansa (Conrad)
Scala pachypleura (Conrad)
Vermetus virginicus (Conrad)
Turritella variabilis var. exaltata Conrad
Fissuridea marylandica (Conrad)

Locality 38, upper part of zone 10, Calvert, north of Dares Beach.

Pelecypods
Atrina harrisii Dall
Ostrea sellæformis var. thomasii Glenn?
Chlamys madisonius (Say)
Anomia sp. indet.
Astarte cuneiformis Conrad
Astarte thomasii Conrad
Eucrassatella melina (Conrad)
Cardium leptopleurum Conrad
Antigona staminea (Conrad)
Dosinia acetabulum Conrad
Chione latilirata (Conrad)
Venus rileyi Conrad
Corbula inæqualis Say
Panopea whitfieldi Dall

Gastropods
Vermetus virginicus (Conrad)
Turritella variabilis var. cumberlandia Conrad
Fissuridea marylandica (Conrad)

Locality 62, zone 10, Calvert, Hollin Cliff.

Pelecypods
Ostrea percrassa Conrad
Pecten humphreysii Conrad
Chlamys madisonius (Say)
Chlamys madisonius var. near marylandicus
Astarte cuneiformis Conrad
Venericardia granulata Say
Corbula elevata Conrad
Corbula inæqualis Say

Gastropods
Turritella indenta Conrad

Scaphopods
Dentalium danai Meyer?

Additional species observed, but not collected:
Pedalion maxillata (Deshayes)
Antigona staminea (Conrad)

Locality 13, zone 10, Calvert Hollin Cliff.

Pelecypods
Nucula sp. indet.
Anadara subrostrata (Conrad)
Atrina harrisii Dall
Pedalion maxillata (Deshayes)
Ostrea percrassa Conrad
Chlamys madisonius (Say)
Astarte cuneiformis Conrad
Venericardia granulata Say
Phacoides crenulatus (Conrad)
Venus sp. indet.
Antigona staminea (Conrad)
Corbula elevata Conrad
Corbula inæqualis Say
Martesia ovalis (Say)?

Gastropods
Ecphora (fragment)
Turritella indenta Conrad
Turritella variabilis Conrad

Additional species observed, but not collected:
Eucrassatella melina (Conrad)
Cardium sp. indet.
Dosinia acetabulum Conrad

Locality 9, zone 10, Calvert, ''Old Walls Place,'' Charles County.

Pelecypods
Nucula proxima Say
Leda liciata (Conrad)
Leda liciata var. amydra Dall
Glycymeris parilis (Conrad)

Anadara subrostrata (Conrad)
Pedalion maxillata (Deshayes)
Chlamys madisonius (Say)
Amusium cerinum (Conrad)
Anomia sp. indet.
Modiolus ducatellii (Conrad)
Astarte cuneiformis Conrad
Astarte cuneiformis var. obesa Dall
Astarte cuneiformis var. calvertensis Glenn
Astarte exaltata Conrad
Astarte thomasii Conrad
Eucrassatella melina (Conrad)
Venericardia granulata Say
Saxolucina (Megaxinus) foremani (Conrad)
Saxolucina (Megaxinus) anodonta (Say)
Phacoides crenulatus (Conrad)
Phacoides trisulcatus (Conrad)
Phacoides prunus Dall
Erycina sp. indet.
Cardium craticuloide Conrad
Cardium laqueatum Conrad
Isocardia markoëi Conrad
Isocardia mazlea Glenn
Dosinia acetabulum Conrad
Macrocallista marylandica (Conrad)
Callocardia subnasuta (Conrad)
Antigona staminea (Conrad)
Chione latilirata (Conrad)
Venus rileyi Conrad
Tellina declivis Conrad
Tellina sp. indet.
Semele carinata (Conrad)
Mactra clathrodon Lea
Corbula idonea Conrad
Corbula elevata Conrad
Corbula inæqualis Say
Saxicava arctica (Linné)
Panopea whitfieldi Dall

Gastropods

Acteon shilohensis Whitfield
Retusa conulus (Deshayes)
Retusa calvertensis Martin
Pleurotoma communis var. protocommunis Martin
Surcula rugata (Conrad)
Mangilia parva (Conrad)
Drillia pseudeburnea (Heilprin)
Marginella calvertensis Martin
Scaphella typus (Conrad)
Scaphella solitaria (Conrad)
Fulgur coronatum var. rugosum Conrad
Siphonalia devexa (Conrad)
Ptychosalpinx lienosa (Conrad)
Ecphora tricostata Martin

Ecphora quadricostata var. umbilicata (Wagner)
Scala sayana Dall
Scala prunicola Martin
Scala pachypleura (Conrad)
Eulima migrans Conrad
Odostomia conoidea (Brocchi)
Turbonilla gubernatoria Martin?
Cerithiopsis calvertensis Martin
Vermetus graniferus (Say)
Vermetus virginicus (Conrad)
Turritella indenta Conrad
Turritella plebeia Say
Turritella variabilis var. exaltata Conrad
Turritella variabilis var. cumberlandia Conrad
Crucibulum costatum (Say)
Calyptræa aperta (Solander)
Crepidula fornicata (Linné)
Xenophora conchyliophora (Born)
Polynices heros (Say)
Calliostoma philanthropus (Conrad)
Teinostoma calvertense Martin
Teinostoma liparum (H. C. Lea)
Fissuridea marylandica (Conrad)

Scaphopods

Dentalium attenuatum Say
Dentalium danai Martin (not Meyer)
Cadulus thallus (Conrad)

Zone 14

Locality 54, zone 14, Calvert, north of Randle Cliff Beach.

Pelecypods

Isocardia fraterna var. marylandica, n. var.
Chione parkeria Glenn

Locality 53, zone 14, Calvert, immediately south of old Plum Point Wharf.

Pelecypods

Chlamys madisonius (Say)
Anomia sp. indet.
Astarte cuneiformis Conrad
Eucrassatella melina (Conrad)
Diplodonta subvexa (Conrad)
Isocardia fraterna var. marylandica, n. var.
Dosinia acetabulum Conrad
Chione parkeria Glenn
Corbula idonea Conrad
Corbula inæqualis Say

Gastropods

Turritella variabilis var. A Martin

Locality 46, zone 14, Calvert, 2-3 miles south of old Plum Point Wharf.

Pelecypods

Chlamys madisonius (Say)
Anomia sp. indet.

Chione parkeria Glenn

Locality 63, zone 14, Calvert, north of Dares Beach.

Pelecypods
Chlamys madisonius (Say)
Anomia aculeata Gmelin
Astarte cuneiformis Conrad
Isocardia fraterna var. marylandica, n. var.
Chione parkeria Glenn

Locality 45, zone 14, Calvert, from south of the mouth of Parker Creek to Governor Run.

Pelecypods
Chlamys madisonius (Say)
Chlamys madisonius near C. marylandicus (Wagner)
Anomia sp. indet.
Astarte castrana Glenn?
Eucrassatella melina (Conrad)
Isocardia fraterna var. marylandica, n. var.
Isocardia ignolea Glenn?
Venus mercenaria Linné
Chione parkeria Glenn
Lucinoma contracta (Say)
Corbula idonea Conrad
Gastropods
Ecphora tricostata Martin
Ecphora quadricostata var. umbilicata (Wagner)

Locality 26, zone 14, Calvert, north of Governor Run.

Pelecypods
Chlamys madisonius (Say)
Anomia aculeata Gmelin
Lucinoma contracta (Say)
Cardium laqueatum Conrad
Isocardia fraterna var. marylandica, n. var.
Dosinia acetabulum Conrad
Venus campechiensis var. capax (Conrad)?
Gastropods
Ecphora tricostata Martin
Ecphora quadricostata var. umbilicata (Wagner)

CHOPTANK FORMATION

Zone 16

Locality 23, zone 16, Choptank, north of Calvert Beach.

Pelecypods
Yoldia lævis (Say)
Anadara staminea Say
Pedalion maxillata (Deshayes)
Chlamys madisonius (Say)
Pandora crassidens Conrad?

Astarte thisphila Glenn
Eucrassatella turgidula (Conrad)
Lucinoma contracta (Say)
Phacoides crenulatus (Conrad)
Diplodonta subvexa (Conrad)
Cardium sp. indet.
Isocardia fraterna var. marylandica, n. var.
Dosinia acetabulum Conrad
Callocardia subnasuta (Conrad)
Venus plena (Conrad)
Abra longicallus (Scacchi)
Semele carinata (Conrad)
Asaphis centenaria (Conrad)
Ensis ensiformis Conrad
Spisula delumbis (Conrad)?
Mactra clathrodon Lea
Corbula idonea Conrad
Corbula inæqualis Say
Panopea whitfieldi Dall

Gastropods
Ecphora tricostata Martin
Turbonilla interrupta (Totten)
Vermetus graniferus (Say)
Turritella plebeia Say
Turritella variabilis var. cumberlandia Conrad
Polynices heros (Say)
Teinostoma liparum (H. C. Lea)

Scaphopods
Cadulus thallus (Conrad)

Locality 24, zone 16, Choptank, south of Calvert Beach.

Pelecypods
Chlamys madisonius (Say)
Eucrassatella turgidula (Conrad)
Lucinoma contracta (Say)
Phacoides crenulatus (Conrad)
Diplodonta subvexa (Conrad)
Isocardia fraterna var. marylandica, n. var.
Dosinia acetabulum Conrad
Callocardia subnasuta (Conrad)
Venus plena (Conrad)
Asaphis centenaria (Conrad)
Corbula inæqualis Say
Panopea goldfussii Wagner
Saxicava arctica (Linné)

Gastropods
Ecphora tricostata Martin
Ecphora quadricostata var. umbilicata (Wagner)

Zone 17

Locality 47, fallen blocks of zone 17, Choptank, south of the mouth of Parker Creek.

Pelecypods
Chlamys madisonius (Say)
Atrina harrisii Dall

Mytilus conradinus d'Orbigny
Eucrassatella turgidula (Conrad)
Venericardia granulata Say
Saxolucina (Megaxinus) anodonta (Say)
Diplodonta acclinis (Conrad)
Isocardia fraterna var. marylandica, n. var.
Macrocallista marylandica (Conrad)
Asaphis centenaria (Conrad)
Spisula sp. indet.
Mactra clathrodon Lea
Gastropods
Ecphora quadricostata var. umbilicata (Wagner)
Turritella variabilis var. cumberlandia Conrad
Calliostoma aphelium Dall

Locality 57, zone 17, Choptank, south of Scientists' Cliffs.
Pelecypods
Chlamys madisonius (Say)
Modiolus ducatellii (Conrad)
Mytilus conradinus d'Orbigny
Astarte thisphila Glenn
Eucrassatella turgidula (Conrad)
Cardita protracta (Conrad)
Phacoides crenulatus (Conrad)
Diplodonta acclinis (Conrad)
Isocardia fraterna var. marylandica, n. var.
Macrocallista marylandica (Conrad)
Callocardia subnasuta (Conrad)
Venus mercenaria Linné
Metis biplicata (Conrad)
Asaphis centenaria (Conrad)
Mactra clathrodon Lea
Corbula idonea Conrad
Gastropods
Turritella variabilis var. cumberlandia Conrad
Crucibulum multilineatum (Conrad)
Polynices heros (Say)
Calliostoma aphelium Dall

Locality 34, zone 17, Choptank, roadcut west of Governor Run.
Pelecypods
Chlamys madisonius (Say)
Astarte thisphila Glenn
Cardita protracta (Conrad)
Isocardia fraterna var. marylandica, n. var.
Corbula idonea Conrad

Locality 27, zone 17, Choptank, north of Calvert Beach.
Pelecypods
Nucula proxima Say
Nucula taphria Dall
Yoldia lævis (Say)
Anadara staminea (Say)
Atrina harrisii Dall
Pedalion maxillata (Deshayes)
Ostrea sp. indet.

Chlamys madisonius (Say)
Chlamys marylandicus (Wagner)
Anomia aculeata Gmelin
Mytilus conradinus d'Orbigny
Modiolus ducatellii (Conrad)
Astarte thisphila Glenn
Eucrassatella turgidula (Conrad)
Venericardia granulata Say
Cardita protracta (Conrad)
Saxolucina (Megaxinus) anodonta (Say)
Lucinoma contracta (Say)
Phacoides crenulatus (Conrad)
Diplodonta acclinis (Conrad)
Diplodonta subvexa (Conrad)
Aligena æquata (Conrad)
Erycina calvertensis Glenn?
Cardium laqueatum Conrad
Isocardia fraterna var. marylandica, n. var.
Dosinia acetabulum Conrad
Macrocallista marylandica (Conrad)
Venus mercenaria Linné
Venus plena (Conrad)
Venus campechiensis var. capax (Conrad)
Metis biplicata (Conrad)
Abra longicallus (Scacchi)
Asaphis centenaria (Conrad)
Psammobia gubernatoria Glenn
Ensis ensiformis Conrad
?Mactra clathrodon Lea
Corbula idonea Conrad
Corbula inæqualis Say
Corbula cuneata Say
Saxicava arctica (Linné)
Panopea whitfieldi Dall
Panopea goldfussii Wagner
Panopea americana Conrad
Gastropods
Pleurotoma bellacrenata Conrad
Cancellaria alternata Conrad
Marginella, n. sp.
Scaphella typus (Conrad)
Scaphella solitaria (Conrad)
Fulgur spiniger (Conrad), variety
Fulgur coronatum var. rugosum Conrad
Siphonalia devexa (Conrad)
Chrysodomus patuxentensis Martin
Columbella communis (Conrad)
Columbella calvertensis Martin?
Ecphora tricostata Martin
Ecphora quadricostata var. umbilicata (Wagner)
Turbonilla nivea Stimpson
Turbonilla interrupta (Totten)
Turritella plebeia Say

Turritella variabilis var. cumberlandia Conrad
Crucibulum costatum (Say)
Crucibulum multilineatum Conrad
Polynices heros (Say)
Polynices duplicatus (Say)
Polynices hemicryptus (Gabb)?
Calliostoma philanthropus (Conrad)
Calliostoma aphelium Dall
Teinostoma liparum (H. C. Lea)
Teinostoma calvertense Martin
Teinostoma greensboroënse Martin
Fissuridea griscomi (Conrad)

Scaphopods
Cadulus thallus (Conrad)

Locality 25, zone 17, Choptank, south of Calvert Beach.

Pelecypods
Nucula taphria Dall
Nucula sinaria Dall?
Anadara staminea (Say)
Pedalion maxillata (Deshayes)
Chlamys madisonius (Say)
Chlamys marylandicus (Wagner)
Mytilus conradinus d'Orbigny
Astarte thisphila Glenn
Eucrassatella turgidula (Conrad)
Cardita protracta (Conrad)
Saxolucina (Megaxinus) anodonta (Say)
Phacoides crenulatus (Conrad)
Diplodonta acclinis (Conrad)
Aligena æquata (Conrad)
Bornia mactroides (Conrad)?
Solecardia cossmanni Dall
Isocardia fraterna var. marylandica, n. var.
Dosinia acetabulum Conrad
Venus campechiensis var. capax (Conrad)
Metis biplicata (Conrad)
Abra longicallus (Scacchi)
Semele carinata (Conrad)
Semele carinata var. compacta Dall
Semele subovata (Say)
Asaphis centenaria (Conrad)
Psammobia gubernatoria Glenn
Ensis ensiformis Conrad
Mactra clathrodon Lea
Corbula idonea Conrad
Corbula inæqualis Say
Corbula cuneata Say
Saxicava arctica (Linné)
Panopea americana Conrad

Gastropods
Volvula iota var. marylandica Martin?
Cancellaria alternata Conrad

Scaphella typus (Conrad)
Siphonalia devexa (Conrad)
Nassa peraltoides Martin
Coralliophila cumberlandiana (Gabb)
Ecphora quadricostata var. umbilicata (Wagner)
Vermetus graniferus (Say)
Turritella plebeia Say
Turritella variabilis var. cumberlandia Conrad
Crucibulum multilineatum Conrad
Crepidula plana Say
Crepidula fornicata (Linné)
Polynices heros (Say)
Calliostoma philanthropus (Conrad)
Calliostoma aphelium Dall
Fissuridea marylandica (Conrad)
Fissuridea griscomi (Conrad)

Locality 44, zone 17, Choptank, north of Long Beach.

Pelecypods
Anadara staminea (Say)
Atrina harrisii Dall
Chlamys madisonius (Say)
Mytilus conradinus d'Orbigny
Astarte thisphila Glenn
Eucrassatella turgidula (Conrad)
Saxolucina (Megaxinus) anodonta (Say)
Lucinoma contracta (Say)
Phacoides crenulatus (Conrad)
Cardium laqueatum Conrad
Isocardia fraterna var. marylandica, n. var.
Dosinia acetabulum Conrad
Macrocallista marylandica (Conrad)
Semele subovata (Say)
Asaphis centenaria (Conrad)
Mactra clathrodon Lea
Corbula idonea Conrad
Corbula inæqualis Say
Panopea goldfussii Wagner
Panopea americana Conrad

Gastropods
Scaphella typus (Conrad)
Ecphora quadricostata var. umbilicata (Wagner)
Turritella plebeia Say
Turritella variabilis var. cumberlandia Conrad
Crucibulum multilineatum Conrad
Polynices heros (Say)
Calliostoma philanthropus (Conrad)

Scaphopods
Cadulus thallus (Conrad)

Locality 56, zone 17, Choptank, south of Flag Pond.

Pelecypods
Anadara staminea (Say)

Astarte thisphila Glenn
Eucrassatella turgidula (Conrad)
Isocardia fraterna var. marylandica, n. var.
Semele subovata (Say)
Corbula idonea Conrad
Gastropods
Ecphora quadricostata var. umbilicata (Wagner)
Turritella plebeia Say
Turritella variabilis var. cumberlandia Conrad

Locality 7, zone 17, Choptank, north of Jones Wharf.
Pelecypods
Chlamys madisonius (Say)
Chlamys madisonius near C. marylandicus (Wagner)
Chlamys marylandicus (Wagner)
Modiolus sp. indet.
Astarte thisphila Glenn
Eucrassatella turgidula (Conrad)
Cardita protracta (Conrad)
Saxolucina (Megaxinus) anodonta (Say)
Phacoides crenulatus (Conrad)
Aligena æquata (Conrad)
Cardium laqueatum Conrad
Isocardia fraterna var. marylandica, n. var.
Dosinia acetabulum Conrad
Macrocallista marylandica (Conrad)
Venus campechiënsis var. cuneata (Conrad)
Metis biplicata (Conrad)
Asaphis centenaria (Conrad)
Semele carinata (Conrad)
Semele subovata (Say)
Ensis ensiformis Conrad
Mactra clathrodon Lea
Corbula inæqualis Say
Gastropods
Siphonalia devexa (Conrad)
Ecphora quadricostata var. umbilicata (Wagner)
Scala sayana Dall
Turritella plebeia Say
Turritella variabilis var. cumberlandia Conrad
Crucibulum costatum (Say)
Crucibulum multilineatum (Conrad)
Crepidula plana Say
Polynices heros (Say)
Polynices hemicryptus (Gabb)
Calliostoma philanthropus (Conrad)
Calliostoma aphelium Dall
Fissuridea griscomi (Conrad)
Scaphopods
Cadulus thallus (Conrad)

Localities 6, 10, 21, zone 17, Choptank, south of Jones Wharf.
Pelecypods
Nucula proxima Say

Anadara staminea (Say)
Atrina harrisii Dall
Pedalion maxillata (Deshayes)
Chlamys madisonius (Say)
Chlamys madisonius near C. marylandicus (Wagner)
Chlamys marylandicus (Wagner)
Anomia aculeata Gmelin
Mytilus conradinus d'Orbigny
Astarte thisphila Glenn
Astarte obruta Conrad (1 specimen)
Eucrassatella turgidula (Conrad)
Venericardia granulata Say
Cardita protracta (Conrad)
Saxolucina (Megaxinus) anodonta (Say)
Lucinoma contracta (Say)
Phacoides crenulatus (Conrad)
Diplodonta acclinis (Conrad)
Aligena æquata (Conrad)
Cardium laqueatum Conrad
Isocardia fraterna var. marylandica, n. var.
Dosinia acetabulum Conrad
Macrocallista marylandica (Conrad)
Callocardia subnasuta (Conrad)
Venus mercenaria Linné
Venus campechiensis var. cuneata (Conrad)
Metis biplicata Conrad
Semele subovata (Say)
Asaphis centenaria (Conrad)
Psammobia gubernatoria Glenn
Ensis ensiformis Conrad
Spisula marylandica Dall
Mactra clathrodon Lea
Corbula idonea Conrad
Corbula inæqualis Say
Corbula cuneata Say
Panopea goldfussii Wagner
Panopea americana Conrad
Martesia ovalis (Say)
Gastropods
Pleurotoma communis Conrad
Surcula rugata Conrad
Scaphella typus (Conrad)
Fulgur spiniger (Conrad), variety
Fulgur coronatum var. rugosum Conrad
Siphonalia devexa (Conrad)
Ecphora quadricostata var. umbilicata (Wagner)
Ecphora tricostata Martin
Turritella plebeia Say
Turritella variabilis var. cumberlandia Conrad

Crucibulum costatum (Say)
Crucibulum multilineatum (Conrad)
Crucibulum, n. sp.
Crepidula fornicata (Linné)
Crepidula plana Say
Polynices heros (Say)
Calliostoma philanthropus (Conrad)
Calliostoma aphelium Dall
Fissuridea griscomi (Conrad)
Scaphopods
Cadulus thallus (Conrad)

Locality 59, zone 17, Choptank, south of Jones Wharf.

Pelecypods
Nucula proxima Say
Nucula taphria Dall
Anadara staminea (Say)
Chlamys madisonius (Say)
Chlamys madisonius near C. marylandicus (Wagner)
Chlamys marylandicus (Wagner)
Anomia aculeata Gmelin
Mytilus conradinus d'Orbigny
Astarte thisphila Glenn
Astarte obruta Conrad (1 specimen)
Eucrassatella turgidula (Conrad)
Saxolucina (Megaxinus) anodonta (Say)
Phacoides crenulatus (Conrad)
Diplodonta acclinis (Conrad)
Aligena æquata (Conrad)
Isocardia fraterna var. marylandica, n. var.
Dosinia acetabulum Conrad
Macrocallista marylandica (Conrad)
Asaphis centenaria (Conrad)
Semele carinata (Conrad)
Semele subovata (Say)
Psammobia gubernatoria Glenn
Ensis ensiformis Conrad
Spisula marylandica Dall
Mactra clathrodon Lea
Corbula idonea Conrad
Corbula inæqualis Say
Corbula cuneata Say
Gastropods
Scaphella typus (Conrad)
Cancellaria alternata Conrad
Ecphora quadricostata var. umbilicata (Wagner)
Turritella plebeia Say
Turritella variabilis var. cumberlandia Conrad
Crucibulum costatum (Say)
Crucibulum multilineatum (Conrad)
Crepidula plana Say
Polynices heros (Say)
Calliostoma philanthropus (Conrad)

Callistoma aphelium Dall

Zone 18

Locality 49, zone 18, Choptank, north of Scientists' Cliffs.

Pelecypods

Anadara staminea (Say)
Chlamys madisonius (Say)
Astarte obruta Conrad
Eucrassatella turgidula (Conrad)
Phacoides crenulatus (Conrad)
Isocardia fraterna var. marylandica, n. var.
Dosinia acetabulum Conrad
Venus sp. indet.
Semele subovata (Say)
Corbula idonea Conrad
Corbula inæqualis Say
Panopea americana Conrad

Gastropods

Turritella variabilis var. C Martin

Scaphopods

Cadulus thallus (Conrad)

Locality 50, *Arca* band in zone 18, Choptank, north of Scientists' Cliffs.

Pelecypods

Anadara staminea (Say)

Zone 19

Locality 12, probably zone 19, Choptank, from roadcut on road leading south from Plum Point to Dares Beach.

Pelecypods

Chlamys madisonius (Say)
Ostrea carolinensis Conrad
Corbula inæqualis Say

Gastropods

Ecphora quadricostata var. umbilicata (Wagner)

Locality 15, zone 19, Choptank, north of Camp Conoy.

Pelecypods

Anadara staminea (Say)
Chlamys madisonius (Say)
Mytilus sp. indet.
Astarte obruta Conrad
Eucrassatella marylandica (Conrad)
Saxolucina (Megaxinus) anodonta (Say)
Phacoides crenulatus (Conrad)
Diplodonta acclinis (Conrad)
Aligena æquata (Conrad)
Cardium laqueatum Conrad
Dosinia acetabulum Conrad
Macrocallista marylandica (Conrad)
Venus campechiensis var. capax (Conrad)
Venus plena (Conrad) ?
Semele subovata (Say)
Psammobia gubernatoria Glenn
Ensis ensiformis Conrad
Corbula idonea Conrad

Corbula inæqualis Say
Corbula cuneata Say
Panopea americana Conrad
Gastropods
Ecphora quadricostata var. umbilicata (Wagner)
Turritella variabilis var. cumberlandia Conrad
Polynices duplicatus (Say)
Scaphopods
Cadulus thallus (Conrad)

Locality 33, zone 19, Choptank, roadcut west of Governor Run.
Pelecypods
Anadara staminea (Say)
Chlamys madisonius (Say)
Ostrea carolinensis Conrad
Pandora sp. indet.
Astarte obruta Conrad
Eucrassatella marylandica (Conrad)
Saxolucina (Megaxinus) anodonta (Say)
?Erycina americana Dall
Dosinia acetabulum Conrad
Mactra clathrodon Lea
Corbula idonea Conrad
Corbula inæqualis Say
Gastropods
Ecphora quadricostata var. umbilicata (Wagner)
Turritella variabilis var. cumberlandia Conrad
Polynices heros (Say)

Locality 51, zone 19, Choptank, north of Camp Boy Haven.
Pelecypods
Anadara staminea (Say)
Chlamys madisonius (Say)
Ostrea carolinensis Conrad
Modiolus ducatellii Conrad
Astarte obruta Conrad
Eucrassatella marylandica (Conrad)
Macrocallista marylandica (Conrad)
Spisula marylandica Dall
Corbula idonea Conrad
Corbula inæqualis Say
Gastropods
Ecphora quadricostata var. umbilicata (Wagner)

Locality 55, zone 19, Choptank, south of Flag Pond.
Pelecypods
Anadara staminea (Say)
Chlamys madisonius (Say)
Ostrea sp. indet.
Astarte obruta Conrad
Eucrassatella marylandica (Conrad)
Saxolucina (Megaxinus) anodonta (Say)
Macrocallista marylandica (Conrad)
Corbula idonea Conrad
Corbula inæqualis Say

Gastropods
Turritella terebriformis Dall
Polynices duplicatus (Say)
Locality 60, zone 19, Choptank, south of Jones Wharf.
Pelecypods
Chlamys madisonius (Say)
Ostrea carolinensis Conrad?
Eucrassatella marylandica (Conrad)

SUMMARY AND CONCLUSIONS

In summarizing the results of this study, material presented in the introduction will not be repeated. It will suffice to state that three main contributions have so far been made:—(1) lists of species from each horizon and locality visited by the writer, (2) a detailed study of eleven important genera of pelecypods, and (3) the chart showing the range, distribution, and abundance of the most important pelecypods. The writer's method of study was described, and recognition of the wide variation shown in large suites of specimens of a single species was pointed out as one of its results.

In the section on stratigraphy the areal distribution and important outcrops of the Miocene were described. The subdivisions of the Maryland Miocene as given by Harris and by Shattuck were summarized. It was pointed out that Shattuck's zones are not true paleontologic zones, but rather, beds, and that some of them cannot be recognized in the field. Shattuck's zones are known principally from a linear section along the west shore of Chesapeake Bay, and have been identified inland at only a few localities.

In the following pages there will be given a summary of information on the distribution of species which have restricted ranges. Such species have great stratigraphic value. Most of this information was included in the systematic descriptions, but part of it has not been presented before. This summary includes accounts of variations in the abundance of fossils in different beds, and at different localities within the same bed; differences in the areal and stratigraphic distribution of individual species; and areal and stratigraphic variations in the forms themselves.

Fossils as a whole are much more abundant in some beds than in others. "Zones" 10, 17, and 19 are outstanding as the most fossiliferous in the section. Probably 90 percent or more of the fossils in most Maryland Miocene collections have come from these three beds. Some of the other beds do carry fossils which, were it not for the contrast, would be considered abundant. These other beds have usually been neglected by collectors, because collecting was so much easier and more profitable from the principal shell beds.

The different fossil bands are listed below in the approximate order of abundance of fossils in proportion to the mass of matrix:

Zone 4, *Ostrea percrassa* bed. (Entire bed is only 3-4 inches thick.)
Zones 10, 17, 19
Zone 14
Zones 5-9, inclusive. *Corbula elevata* beds.
Zone 16
Zones 12 and 18
Zones 11 and 13

Probably well over half of the mass of zones 4, 10, 17, and 19 is made up of shell material; no other bed has more than a quarter of its mass so formed.

In general, pelecypods are more abundant than gastropods in the Calvert and Choptank formations, at least in total number of specimens, if not in number of species. In the St. Mary's formation the gastropods are more abundant in number of individuals and probably also in number of species. The relative numbers of pelecypods and gastropods do not vary materially in different beds of the Calvert and Choptank.

Of the three most fossiliferous zones, 10, 17, and 19, zone 10 has the greatest variety of forms, zone 17 the second greatest, and zone 19 the least. It is rather striking that so few forms make up the main mass of shell material in zone 19. Large *Chlamys madisonius, Macrocallista marylandica,* and several species of *Venus* contribute most to the shell volume. The other most common forms are *Anadara staminea, Eucrassatella marylandica, Astarte obruta, Saxolucina anodonta,* and *Corbula idonea.*

Zone 14 carries a good many fossils in the area where it is best exposed, north of Governor Run. Large *Chlamys madisonius*, *Dosinia acetabulum*, *Isocardia fraterna* var. *marylandica*, *Venus*, and *Ecphora* make up the bulk of the fossils. The shells in this bed are particularly rotten, and are consequently not easy to collect. There is much more mud mixed with sand here than in the richest fossil beds (10, 17, and 19), which have a matrix of almost pure sand.

Zone 16, north and south of Calvert Beach, carries many well-preserved fossils. Particularly striking is the abundance of perfect specimens of double-valved *Lucinoma contracta*, preserved in their living position with the plane between the valves vertical. Nowhere else in the Calvert or Choptank of Maryland is there so striking an example of a fossil being preserved in the same position in which it lived.

There is some variation in the number of specimens of gastropods present in zone 10 at different localities. There are more at Plum Point than at localities farther north along the cliffs. The species are the same, but there are more individuals present at Plum Point. The greatest variety in species of gastropods and pelecypods within zone 10 is found at the "Old Walls Place," locality 9, in Charles County. There are more gastropods found here than even at Plum Point. The species found are mostly the same as those found in zone 10 along the Calvert Cliffs, but there are many more individuals than at any single locality along the cliffs. Practically all the species found at all the cliff localities combined are present at the "Old Walls Place." Some species which were rare along the cliffs are common at that locality,—*Astarte exaltata*, for example. *Turritella*, *Scaphella*, *Siphonalia devexa*, *Fissuridea marylandica*, and *Amusium cerinum* are a few of the forms which are more common there than along the Calvert Cliffs. Also, at locality 9, limpet shells are quite abundant, and *Xenophora conchyliophora* is not nearly so unusual as elsewhere.

Variations in the Pectens and Astartes at different localities in zone 10 are noted in the systematic descriptions of those genera. A thin, flat variety of *Chlamys madisonius* is to be found in zone 10 at the north end of the cliffs, but not elsewhere. A variety of *C. madisonius* which is much like *C. marylandicus* in general appearance was found in the oyster bed, zone 4, south of Randle Cliff Beach, and in zone 10 at Hollin Cliff. Specimens of *Astarte cuneiformis* from the north end of the cliffs are slightly longer and more pointed posteriorly than those from other localities. The difference is not striking, but it is sufficient to separate large suites of specimens from the north end of the cliffs from those farther south.

Anadara subrostrata and *Glycymeris parilis* are slightly larger at the north end of the cliffs than near Plum Point or at the "Old Walls Place." *Macrocallista marylandica* is never so large in zone 10 as in the Choptank formation. It is present in considerable numbers in zone 10, but the specimens are never more than half the size of those in the Choptank. This is similar to the size differences in *Chlamys madisonius* from zone 10 and from the Choptank. Specimens from zone 10 are less than half the size of those commonly found in the Choptank.

Saxolucina anodonta is abundant at the north end of the cliffs, and *Saxolucina foremani* rare. Further south, near Plum Point, the situation is reversed. *S. foremani* is much more abundant, and *S. anodonta* rarer, although the latter is still more abundant than is *S. foremani* at the north end of the cliffs.

Many of the variations in species in different beds and localities can probably best be explained on the basis of ecology. The writer is unable to give definite reasons in any particular case, but she believes that environmental changes are adequate to account for most, if not all, of the differences observed in one bed at different localities, and in many cases to account for differences between different beds. The latter would also be correlative with changes in lithology. It would be logical to expect that some of the changes shown at the north end of the cliffs and at the "Old Walls Place," in Charles County, would be connected with nearer shore conditions, but no direct evidence bearing on this point was found.

The stratigraphic range of some of the species is limited enough to enable one to use them in the field. Such species with limited ranges are enumerated here.

Among the Corbulas, *C. elevata* appears first just above the oyster bed, and continues up through zone 10. It never occurs above zone 10. *C. idonea* appears first in zone 10, and continues throughout the rest of the Calvert and Choptank. One specimen was found in the St. Mary's. *C. inæqualis* appears first in zone 10, and continues throughout the rest of the Calvert, the Choptank, and the St. Mary's. It is the only species of *Corbula* which is at all common in the St. Mary's. *Pecten humphreysii* occurs in zones 5-9 and 10, but never above zone 10.

Several common species are known only from zone 10. These include *Antigona staminea, Isocardia markoëi, Isocardia mazlea, Glycymeris parilis, Anadara subrostrata, Turritella indenta.* Any of these can be used as index fossils for that zone. *Astarte cuneiformis* is common only in zone 10, but is known from zone 14 at one locality. *Xenophora conchyliophora* is known only from zone 10, but it is too rare to be of any real value.

Eucrassatella melina occurs in both zones 10 and 14, but has not been recorded from any of the beds between. It is most common in zone 10.

Chione parkeria is the best index fossil for zone 14, and is very common in that zone. It is limited to the upper part of the Calvert formation, although it is not certain whether it is limited strictly to zone 14. Apparently it is common only in beds above the clay layer, zone 13.

No Arcas at all were found between zones 10 and 16. *Anadara staminea* is characteristic of the Choptank as a whole. It occurs in zones 16-19, and is especially abundant in zone 17 and zone 19.

Metis biplicata, Asaphis centenaria, and *Panopea americana* are species which are all fairly common and characteristic of zone 17 of the Choptank. They have all been found occasionally in zone 10 of the Calvert, but they are not at all common there. Wherever they are found abundantly one can be certain that the horizon is zone 17 of the Choptank.

True *Chlamys marylandicus* is limited to zone 17 of the Choptank. *Eucrassatella turgidula* and *Astarte thisphila* occur in both zones 16 and 17, but are much more common in zone 17. *Eucrassatella turgidula* was also found in zone 18 at one locality. *Cardita protracta* has been found by the writer only in zone 17.

Astarte obruta and *Eucrassatella marylandica* are both restricted to zone 19, with the exception that a few rare specimens of *A. obruta* were found in zone 17. They are nevertheless characteristic of zone 19.

Some forms were apparently gregarious, and they frequently occur in concentrated bands consisting almost exclusively of a single species. The *Ostrea percrassa* bed, zone 4, is evidently such a band. Within zone 10 of the Calvert formation the following are apt to occur in this manner: *Anadara subrostrata, Glycymeris parilis,* and young *Macrocallista marylandica.* At locality 36, immediately south of Randle Cliff Beach, *Cardium leptopleurum* was found in such a band. The specimens were packed together as closely as possible, though other forms were also present. In both zones 17 and 19 in the Choptank, Arcas form conspicuous bands.

No individual band can be traced any great distance, probably never more than a quarter of a mile. Some of the *Arca* bands in the Choptank may be traced this far, but probably none of the bands within zone 10 of the Calvert are so extensive. The bands appear at different horizons within the main fossil beds at different localities. The pelecypods are usually double-valved specimens, and it is apparent from their manner of occurrence that they represent colonies of single species preserved in their living position. The shells show no signs of wear, and it is inconceivable that such bands of one species, with the valves still articulated, could have been formed by the chance rolling together of the shells after the death of the animals.

A similar occurrence of gastropods was found in the St. Mary's formation along the St. Mary's River south of St. Mary's City. Over 20 perfect specimens of *Buccinofusus parilis* were collected from a pocket about two feet long, one foot wide, and six to eight inches thick. A few yards away a large group of *Barnea arcuata* were found in a clay layer about one foot lower stratigraphically than the *Buccinofusus* pocket. The Barneas were obviously in the burrowing position in which they lived. Neither of these occurrences could be described as a band in the same sense as those in the Calvert and Choptank. Rather, they are pockets, but they show just as clearly the positions in which the forms lived.

LOCALITY LIST

The localities of species-occurrence are referred to in the text by number. The numbers are those from the author's personal locality book. Descriptions of the localities are given in the following list, and their locations may be determined on the Calvert and St. Mary's County topographic maps of the Maryland Geological Survey, or on the Prince Frederick, Drum Point, and Leonardtown Quadrangle maps of the United States Geological Survey. The collections were made by the author for the most part, but on some occasions she was accompanied and assisted by others from Bryn Mawr College. Unless otherwise indicated, all localities are along the west shore of Chesapeake Bay, in Calvert County, Maryland. All localities refer to beds of Miocene age.

1, 14, 35. Zone 10, Calvert.—Collected from a stretch extending from a quarter to a half mile north of Randle Cliff Beach; or from half to three-quarters of a mile south of the beginning of the cliffs, south of the first tributary stream south of Chesapeake Beach.

2. Zone 10, Calvert.—From the first high cliffs south of the first stream on the south side of Camp Roosevelt; about a quarter of a mile south of Camp Roosevelt.

3, 11, 28. Zone 10, Calvert.—From locality approximately 1¼ miles south of the old Plum Point Wharf. The locality is immediately north of the first large stream and valley to enter the bay south of the old Plum Point Wharf.

4. Zone 10, Calvert.—From cliffs from half to three-quarters of a mile south of Randle Cliff Beach; or a little more than a quarter of a mile north of Captain Collie Hubbard's place.

5. Zone 10, Calvert.—From roadcut along the main road between the entrance to Camp Roosevelt and Captain Hubbard's place. Roadcut near top of second hill, about half a mile north of the entrance to Camp Roosevelt.

6, 10. Zone 17, Choptank.—From stretch a mile and more southeast of old Jones Wharf, on the southwest side of the Patuxent River, St. Mary's County, Maryland.

7. Zone 17, Choptank.—From stretch about three-quarters of a mile northwest of Jones Wharf, on the southwest side of the Patuxent River, St. Mary's County, Maryland.

8. Zone 24?, St. Mary's.—Collected at intervals along the three-quarter mile stretch from Rosecroft (opposite Windmill Point), north to Chancellor Point on the east side of St. Mary's River, south of St. Mary's City, St. Mary's County, Maryland. Almost all fossils from beneath the indurated layer.

9. Zone 10, Calvert.—Collected from the headwaters of a stream tributary to Swanson Creek, near Patuxent, Charles County, Maryland. Locality is reached by going to Bendix schoolhouse, about one mile east of Patuxent on the road from Patuxent to Benedict, and turning northeast on dirt road to farmhouse known locally as the "Old Walls Place," now occupied by people named Rawlins. Turn into farmhouse grounds (first farm on left side of road), go to right of farmhouse, take first gate to right into field, continue on down farm road to about 100 yds. beyond tobacco barn. Locality is to right of road, about 75 yds. distant.

Above zone 10 in the stream bed was dark, greenish, compact, sandy clay, containing similar fossils, less abundantly.

10. Zone 17, Choptank.—Same locality as number 6.

11. Zone 10, Calvert.—Same locality as number 3.

12. Choptank, probably zone 19.—From roadcut on the road leading south from Plum Point Wharf towards Dares Beach. Slightly more than half a mile south of the Plum Point road intersection; at the top of the second hill from that intersection, or at the top of the first high hill; just south of the Wilson Post Office. Barnacles and large Pectens were the most abundant fossils.

13. Zone 10, Calvert.—From about three-eighths of a mile north of Hollin, or Holland, Cliff, on the east shore of the Patuxent River, Maryland. A few fossils were obtained by digging a hole toward the top of the cliff. The shells were very rotten, apparently in the process of being leached out. There was an indurated layer in the midst of the shells, which varied its vertical position. *Pecten* fragments were most common.

14. Zone 10, Calvert.—Same locality as number 1.

15. Zone 19, Choptank.—From a stretch of cliffs about a mile north of Camp Conoy.

16. Zone ?, St. Mary's.—Little Cove Point.

19. Zone 4, Calvert.—*Ostrea percrassa* from the oyster bed at the beginning of the cliffs south of Chesapeake Beach.

21. Zone 17, Choptank.—From high bluff about half a mile southeast of old Jones Wharf, on the southwest side of the Patuxent River, St. Mary's County, Maryland. Near localities 6 and 10, but not so far down the river.

22. Choptank, probably zone 19.—From a roadcut on state route 2, a short distance north of the entrance to Camp Conoy and Camp Boy Haven.

23. Zone 16, Choptank.—From immediately north of Calvert Beach. From dense, bluish green sandy layer lying between water level and an elevation of about six feet.

24. Zone 16, Choptank.—From immediately south of Calvert Beach; from dense bluish clay.

25. Zone 17, Choptank.—From immediately south of Calvert Beach. Same locality as number 24, but a higher zone.

26. Zone 14, Calvert.—From immediately north of Governor Run or Kenwood Beach.

27. Zone 17, Choptank.—North of Calvert Beach, Maryland, for a stretch of a little over a mile. Same general locality as number 23, but a higher zone.

28. Zone 10, Calvert.—Same locality as numbers 3, 11.

29. Choptank.—From near the west end of Nomini Cliffs, Potomac River, Westmoreland County, Virginia. From blocks fallen from near the top of the cliffs.

30. Choptank.—From the same general locality as number 29, but a little farther east. Collected from the very bottom of the cliffs.

31. Choptank.—From fallen blocks at Stratford Cliffs, Potomac River, Westmoreland County, Virginia.

32. Choptank.—Horsehead Cliffs, Potomac River, Westmoreland County, Virginia.

33. Zone 19, Choptank.—From a roadcut half a mile west of Governor Run.

34. Zone 17, Choptank.—From a roadcut just west of Governor Run; not quite so far west as locality 33.

35. Zone 10, Calvert.—Same locality as numbers 1, 14.

36. Zone 10, Calvert.—Immediately south of Randle Cliff Beach; further north than locality 4.

37. St. Mary's.—Langley's Bluff, St. Mary's County, Maryland.

38. Top of zone 10, Calvert.—From three-quarters to 1½ miles north of Dares Beach. At this locality the top of zone 10 is separated from the main shell mass as a distinct bed. This upper, thin shell layer is almost at the water level in this area, and disappears beneath it at the south end of the stretch. The fauna in it is much the same as that of the main mass of zone 10, but with a few differences. *Glycymeris* is absent; *Phacoides* rare or absent; *Atrina* is especially abundant in fragments. The principal gastropods are *Turritella* (3 species), *Ecphora tricostata, Fissuridea, Dentalium* (smooth form), and worm tubes. *Pecten madisonius* is the most abundant single species.

39. Zone 5 or 6?, Calvert.—From bed carrying small, black pebbles which can be traced into the oyster bed to the north. From a mile or more north of the new Plum Point colony.

40. Zone 4, Calvert.—Ostrea percrassa from the oyster bed immediately south of Randle Cliff Beach.

40-a. Zone 6?, Calvert.—From the same locality, but from the *Corbula* layer above number 40.

40-b. Zone 3?, Calvert.—From three feet below the oyster layer, at the same locality as number 40.

41. Zone 6?, Calvert.—From fallen blocks of the *Corbula* beds, north of Randle Cliff Beach. From the beds in which *Corbula elevata* is most abundant.

42. Zone 5?, Calvert.—From thin fossil bands just above the oyster bed. From fallen blocks, but the source was quite definite. North of Randle Cliff Beach.

43. Top of zone 10, Calvert.—One and a quarter to two miles south of old Plum Point Wharf, Maryland. This overlaps the area included in locality 38; same horizon.

44. Zone 17, Choptank.—Immediately north of Long Beach; or about three-quarters of a mile south of Calvert Beach.

45. Zone 14, Calvert.—Half a mile south of the mouth of Parker Creek.

46. Zone 14, Calvert.—About two miles south of old Plum Point Wharf.

47. Zone 17, Choptank.—From fallen blocks immediately south of the mouth of Parker Creek.

48. Zone 10, Calvert.—From locality approximately 1½ miles south of old Plum Point Wharf. Immediately south of the first large stream and valley to enter the bay south of the old Plum Point Wharf (about a quarter of a mile or less south of localities 3, 11, 28).

49. Zone 18, Choptank.—From fossil band at 56-57½ feet above high tide mark at a locality 1750 feet north of Scientists' Cliffs.

50. Zone 18, Choptank.—From *Arca* band in clay at an elevation of 49½-52 feet above high tide mark, at the same locality as number 49, 1750 feet north of Scientists' Cliffs.

51. Zone 19, Choptank.—From about a mile north of Camp Boy Haven.

52. Zones 5-9?, Calvert.—From fallen blocks of the *Corbula* beds just south of Randle Cliff Beach. The blocks may have come from anywhere between the oyster bed and zone 10.

53. Zone 14, Calvert—From fallen blocks of zone 14 about half a mile south of old Plum Point Wharf.

54. Zone 14?, Calvert.—From fallen blocks from beds above zone 10, north of Randle Cliff Beach. Probably zone 14.

55. Zone 19, Choptank.—From between Camp Conoy and Flag Pond; near the north end of the cliffs, about a mile south of Flag Pond.

56. Zone 17, Choptank.—From same locality as number 55. From the north end of the cliffs. Zone 17 is at beach level at this locality.

57. Zone 17, Choptank.—Nine-tenths of a mile south of Scientists' Cliffs.

59. Zone 17, Choptank.—From about eight-tenths of a mile southeast of old Jones Wharf, on the southwest side of the Patuxent River, St. Mary's County. Fossil bed 19-23 feet above water level at the southeast end of the stretch, 19-25 at the north end. Same general locality as numbers 6, 10.

60. Zone 19, Choptank.—From about a quarter of a mile southeast of old Jones Wharf, on the southwest side of the Patuxent River, St. Mary's County. Zone 19 at an elevation of approximately 36-44 feet above water level.

61. Choptank.—About 8500 feet east of Stratford Wharf, Potomac River, Westmoreland County, Virginia. From a band of fossils 14-20 feet above the river.

62. Zone 10, Calvert.—From about a quarter of a mile north of locality 13, or about five-eighths of a mile north of Hollin, or Holland, Cliff, on the east shore of Patuxent River, Maryland. A small valley separates the two localities. This is the more conspicuous cliff. The fossils were scattered over the surface of the lower parts of the cliff, and it was impossible to reach the actual fossil bed.

63. Zone 14, Calvert.—From north of Dares Beach, (near number 46).

SUMMARY OF LOCALITIES

In the table below the localities are arranged according to stratigraphic sequence and zones. Where there are several localities for the same zone they are arranged in order from the most northerly to the most southerly along the Chesapeake Bay shore. The localities not on the Bay shore are listed last. A few localities not actually on the Bay shore, but less than a mile inland, are listed in their proper place in the north-south sequence.

Zone	*Locality*
St. Mary's	8, 16, 37.
Choptank	
19	12?, 15, 33, 51, 55, 60.
18	49, 50.
17	47, 57, 27, 25, 44, 56, 34, 7, 6, 10, 21, 59.
16	23, 24.
Calvert	
14	54, 53, 46, 63, 45, 26.
10	1, 14, 35, 36, 4, 2, 5, 3, 11, 28, 48, 38, 43, 9, 13, 62.
5-9?	52
6	41, 40a.
5 or 6?	39
5	42
4	19, 40.
3?	40b

Choptank, undifferentiated as to zones; arranged from east to west along the Potomac River, Virginia:—
61, 30, 29, 31, 32.

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VITA

The author was born in Marietta, Ohio, and received her early training in the public schools of that city. She attended Marietta College for one year, and then entered Oberlin College, taking an undergraduate major in geology. During the summer of 1932 she spent seven weeks attending the Oberlin Summer Field Course in geology at a camp in Giles County, Virginia. She received her A.B. degree from Oberlin in 1934. The following autumn she entered the graduate school of Cornell University, and commenced work as a part-time assistant to Prof. G. D. Harris of the Paleontological Research Institution. As a result of working with Prof. Harris's extensive collections, her interest turned toward Tertiary paleontology. In 1936 she received the M.A. degree from Cornell University. The title of her thesis was, "The Eocene Crassatellas of the Atlantic and Gulf Coast Provinces."

Since 1936 she has held an appointment as part-time Demonstrator in Geology at Bryn Mawr College. While in Ithaca she had become interested in the Miocene fossils of Maryland, and as part-time graduate student at Bryn Mawr College she has carried on the present study. The collections on which this study was based were made by the author during the summers of 1936, 1937, and 1938. The summer of 1939 was spent in cataloging type and figured fossil specimens for the Paleontological Research Institution at Ithaca, New York.

PLATES

EXPLANATION OF PLATE 1 (19)

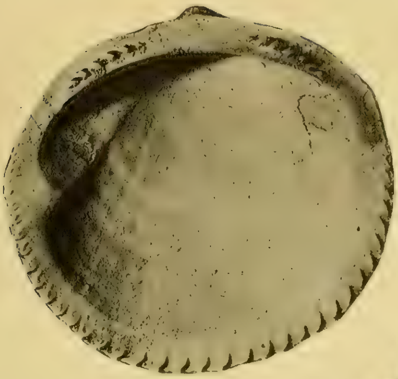
Figure Page

1. **Glycymeris parilis** (Conrad) 15
Interior of left valve from zone 10, Calvert, locality 1, north of Randle Cliff Beach. Length, 52 mm.; height, 51 mm. No. 3909, P. R. I.

2-4. **Anadara subrostrata** (Conrad) 21
2. Interior of left valve from zone 10, Calvert, locality 36, south of Randle Cliff Beach. Length, 44 mm.; height, 31 mm. No. 3910, P. R. I.
3. Exterior of right valve from zone 10, Calvert, locality 36, south of Randle Cliff Beach. Length, 61 mm.; height, 43 mm. No. 3911, P. R. I.
4. Exterior of left valve from zone 10, Calvert, locality 35, north of Randle Cliff Beach. Length, 47 mm.; height, 33 mm. No. 3912, P. R. I.

5-7. **Anadara staminea** (Say) 21
5. Exterior of left valve from zone 17, Choptank, locality 6, south of Jones Wharf. Length, 52 mm.; height, 47 mm. No. 3913, P. R. I.
6, 7. Right valve from zone 19, Choptank, locality 55, south of Flag Pond. Length, 39 mm.; height, 32 mm. No. 3914, P. R. I. Fig. 6, exterior; fig. 7, interior.

8. **Glycymeris parilis** (Conrad) 15
Exterior of right valve from zone 10, Calvert, locality 2, south of Camp Roosevelt. Length, 55 mm.; height, 54 mm. No. 3915, P. R. I.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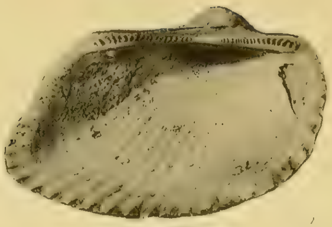
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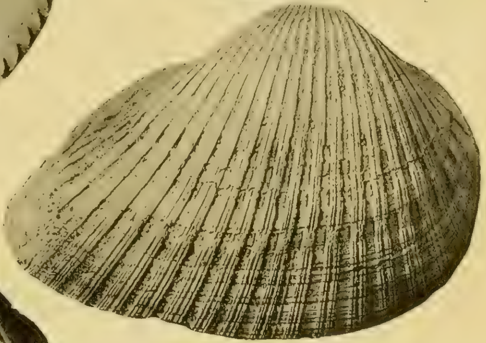

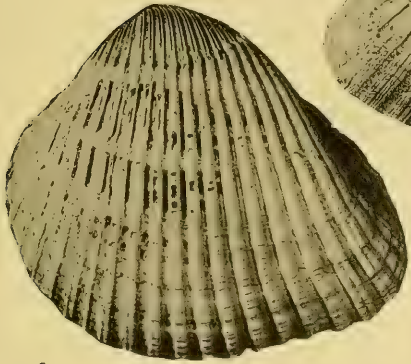
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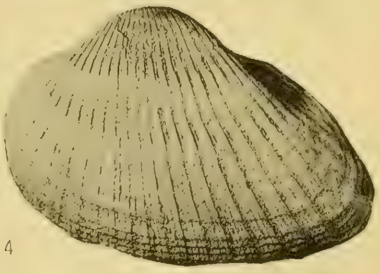
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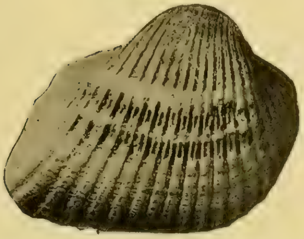

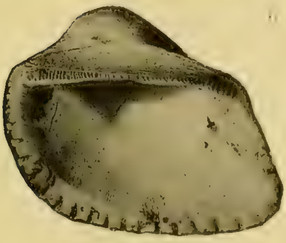
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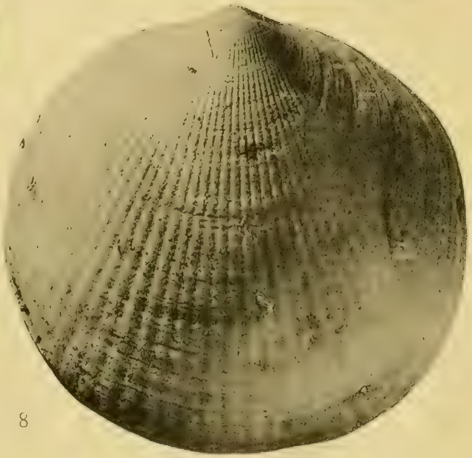
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PLATE 2 (20)

EXPLANATION OF PLATE 2 (20)

Figure Page

1-2. **Pecten humphreysii** Conrad 24

1. Exterior of lower valve from zone 10, Calvert, locality 35, north of Randle Cliff Beach. Length, 41 mm.; height, 35 mm. No. 3916, P. R. I.

2. Exterior of upper valve from zone 10, Calvert, locality 35, north of Randle Cliff Beach. Length, 52 mm.; height 48 mm. No. 3917, P. R. I.

3. **Chlamys madisonius** (Say) 23

This and the specimens illustrated on pl. 2, fig. 6, and pl. 5, figs. 1-2 are representative of the forms found in zone 10 of the Calvert.

Exterior of right valve from zone 10, locality 11, south of old Plum Point Wharf. Length, 66 mm.; height, 66 mm. No. 3918, P. R. I.

4. **Anadara staminea** (Say) 21

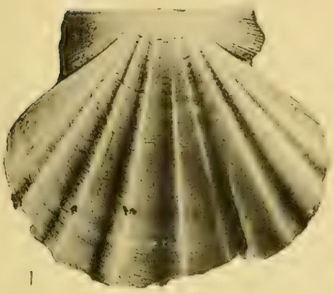
Exterior of left valve from zone 17, Choptank, locality 27, north of Calvert Beach. Length, 35 mm.; height, 34 mm. No. 3919, P. R. I.

5. **Chlamys madisonius** (Say), near **C. marylandicus** 23

Exterior of half of left valve from zone 10, Calvert, locality 62, Hollin Cliff. Length of fragment, 26 mm.; height, 43 mm. No. 3920, P. R. I.

6. **Chlamys madisonius** (Say) 28

Exterior of right valve from zone 10, locality 3, south of old Plum Point wharf. Length, 41 mm.; height, 40 mm. No. 3921, P. R. I.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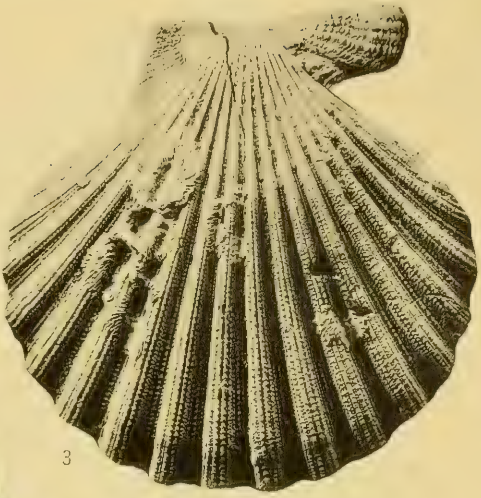
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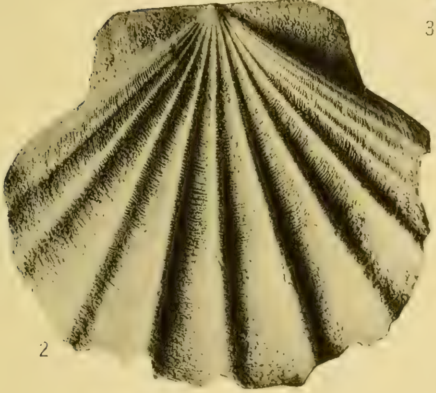
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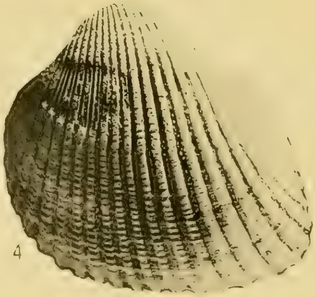
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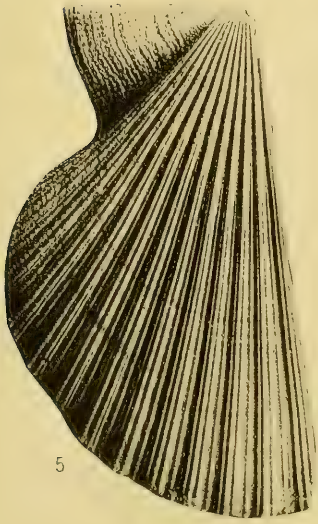
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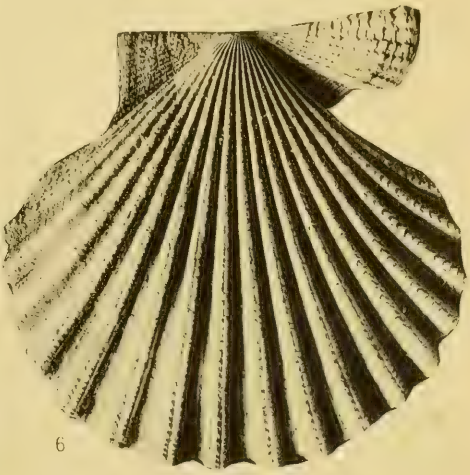
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PLATE 3 (21)

EXPLANATION OF PLATE 3 (21)

Figure		Page
1-3.	**Chlamys madisonius** (Say), near **C. marylandicus**	28

Figures 1-3, and 6, on this plate, and fig. 5 on pl. 2 show some of the variations of **C. madisonius** which are very similar to **C. marylandicus.** The latter species is shown in figs. 4-5 for comparison.

1. Exterior of right valve from zone 17, Choptank, locality 6, south of Jones Wharf. Anterior ear broken. Length, 55 mm.; height, 60 mm. No. 3922, P. R. I.

2. Exterior of left valve picked up on beach north of Jones Wharf. Probably from zone 17, Choptank. Length, 49 mm; height 50 mm. No. 3923, P. R. I.

3. Exterior of left valve picked up on beach north of Jones Wharf. Probably from zone 17, Choptank. Length, 67 mm.; height, 67 mm. No. 3924, P. R. I.

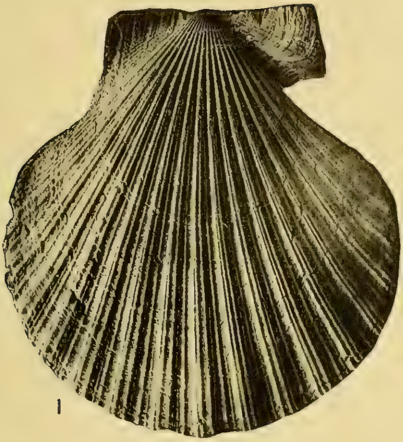
Figure		Page
4-5.	**Chlamys marylandicus** (Wagner)	26

4. Exterior of right valve from zone 17, Choptank, locality 59, south of Jones Wharf. Length, 39 mm.; height, 42 mm. No. 3925, P. R. I.

5. Exterior of left valve from zone 17, Choptank, locality 59, south of Jones Wharf. Length, 60 mm.; height, 63 mm. No. 3926, P. R. I.

Figure		Page
6.	**Chlamys madisonius** (Say), near **C. marylandicus**	28

Exterior of right valve from zone 10, Calvert, locality 62, Hollin Cliff. Length, 28 mm.; height, 30 mm. No. 3927, P. R. I.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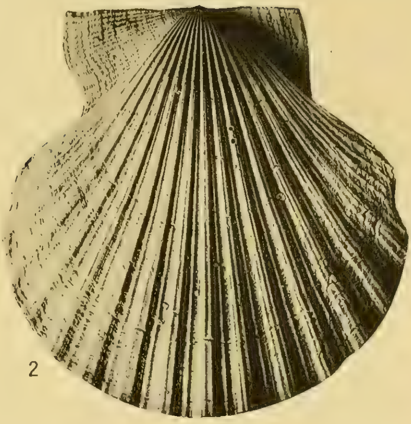
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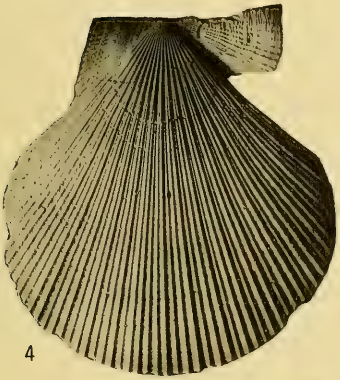
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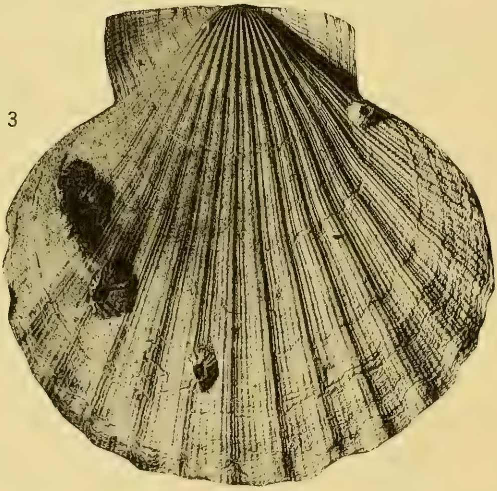
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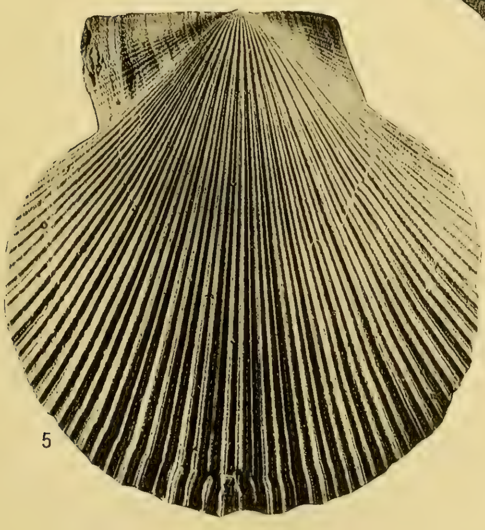
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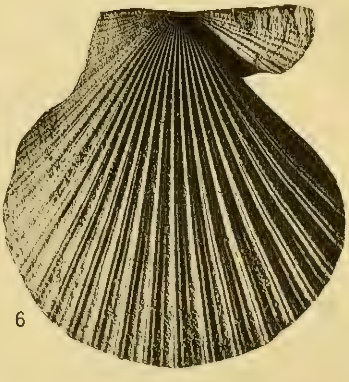
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PLATE 4 (22)

EXPLANATION OF PLATE 4 (22)

Figure Page

1-3. **Chlamys madisonius** (Say), variety 34

These three figures are of the thin flat variety common at the north end of the Calvert Cliffs.

1. Exterior of left valve from zone 10, locality 14, north of Randle Cliff Beach. Length, 30 mm.; height, 32 mm. No. 3928, P. R. I.

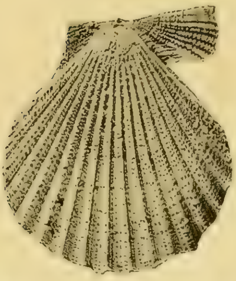
2. Exterior of right valve from zone 10, locality 1, north of Randle Cliff Beach. Length, 20 mm.; height 22.5 mm. No. 3929, P. R. I.

3. Exterior of right valve from zone 10, locality 14, north of Randle Cliff Beach. Length, 23 mm.; height, 26 mm. No. 3930, P. R. I.

4. **Chlamys madisonius** (Say) 28

This and the specimen figured on pl. 5, fig. 3 are typical specimens, such as those on which the original description was based.

Exterior of left valve from zone 19, Choptank, locality 51, north of Camp Boy Haven. Length, 140 mm.; height, 126 mm. No. 3931, P. R. I.



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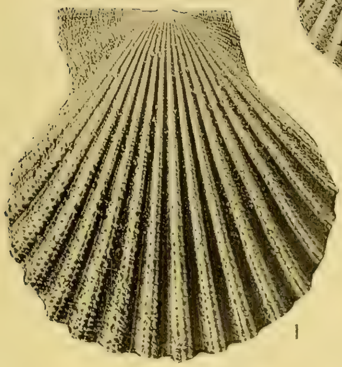

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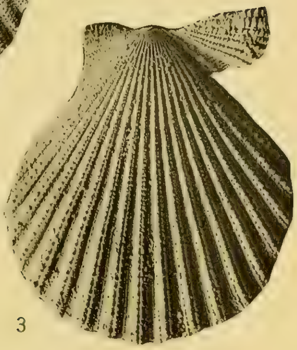

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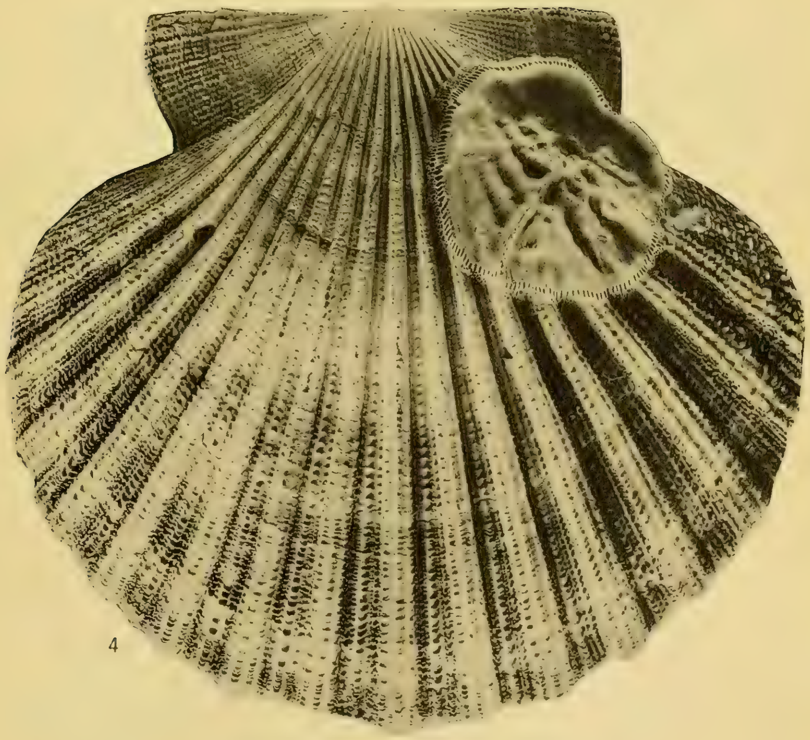

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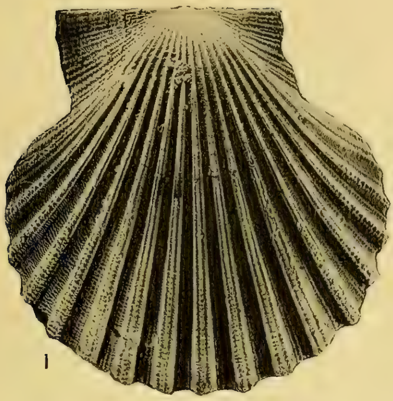
PLATE 5 (23)

EXPLANATION OF PLATE 5 (23)

Figure		Page
1-3.	**Chlamys madisonius** (Say)	28

1. Exterior of left valve from zone 10, locality 11, south of old Plum Point Wharf. Length, 50 mm.; height, 52 mm. No. 3932, P. R. I.
2. Exterior of left valve from zone 10, locality 3, south of old Plum Point Wharf. Length, 57 mm.; height, 52 mm. No. 3933, P. R. I.
3. Exterior of right valve from zone 19, Choptank, locality 51, north of Camp Boy Haven. Length, 154 mm.; height, 143 mm. No. 3934, P. R. I.



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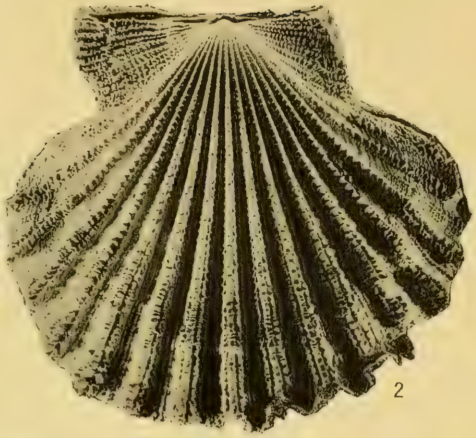

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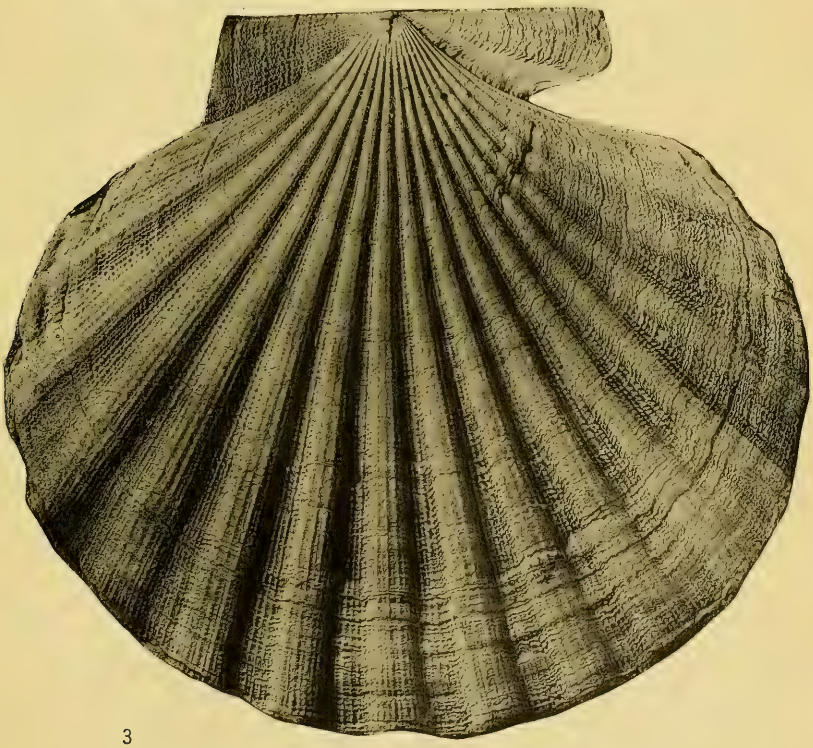

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PLATE 6 (24)

EXPLANATION OF PLATE 6 (24)

Figure Page

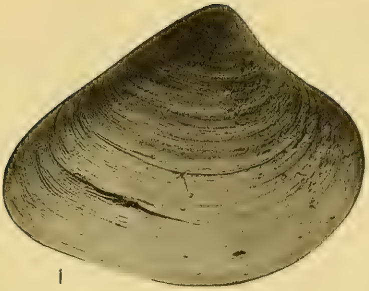
1. **Astarte cuneiformis** var. **obesa** Dall 39
Exterior of right valve from zone 10, Calvert, locality 1, north of Randle Cliff Beach. Length, 30 mm.; height, 23 mm. No. 3935, P. R. I.

2. **Astarte cuneiformis** Conrad 38
Exterior of right valve from zone 10, Calvert, locality 3, south of old Plum Point Wharf. Length, 27 mm.; height, 21 mm. No. 3936, P. R. I.

3-4. **Eucrassatella melina** (Conrad) 49
3. Exterior of left valve from zone 10, Calvert, locality 35, north of Randle Cliff Beach. Length, 69 mm.; height, 46 mm. No. 3937, P. R. I.
4. Exterior of right valve of young specimen from zone 10, Calvert, locality 48, south of old Plum Point Wharf. Length, 51 mm.; height, 32 mm. No. 3938, P. R. I.

5-6. **Astarte cuneiformis** var. **calvertensis** Glenn 39
5. Exterior of left valve from zone 10, Calvert, locality 2, south of Camp Roosevelt. Length, 25 mm.; height, 19 mm. No. 3939, P. R. I.
6. Exterior of right valve from zone 10, Calvert, locality 2, south of Camp Roosevelt. Length, 26 mm.; height, 20 mm. No. 3940, P. R. I.

7. **Eucrassatella turgidula** (Conrad) 50
Exterior of right valve from zone 17, Choptank, locality 6, south of Jones Wharf. Length, 89 mm.; height, 56 mm. No. 3941, P. R. I.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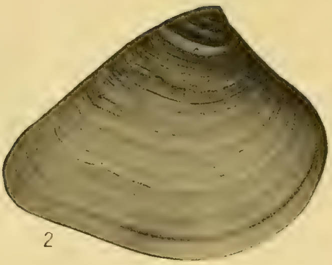
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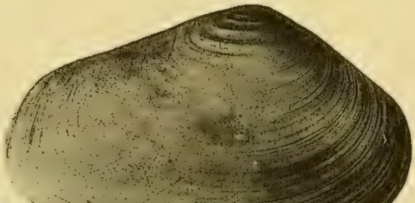
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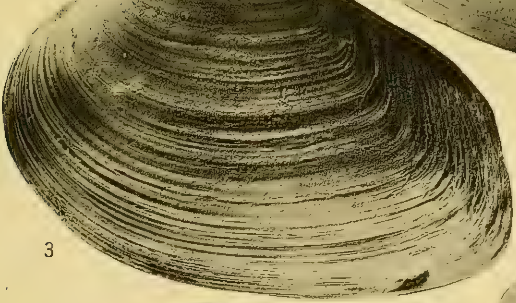
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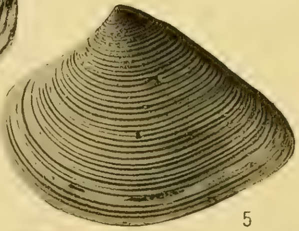
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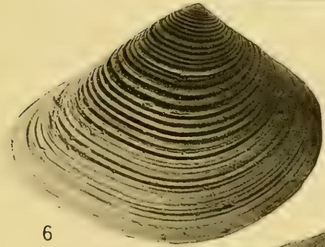
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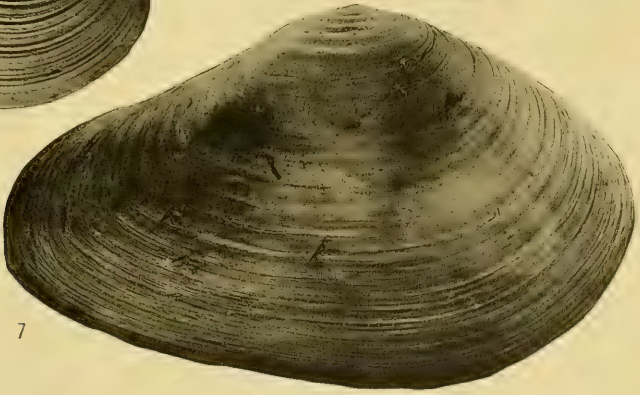
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PLATE 7 (25)

EXPLANATION OF PLATE 7 (25)

Figure Page

1-2. **Astarte thomasii** Conrad. Broad-ribbed variety 41
1. Exterior of right valve from the top of zone 10, Calvert, locality 43, south of old Plum Point Wharf. Length, 18 mm.; height, 15 mm. No. 3942, P. R. I.
2. Exterior of left valve from the top of zone 10, Calvert, locality 43, south of old Plum Point Wharf. Length, 19 mm.; height, 16 mm. No. 3943, P. R. I.

3-4. **Astarte thomasii** Conrad. Fine-ribbed variety 41
3. Exterior of right valve from zone 10, Calvert, locality 9, "Old Walls Place", Charles County. Length, 21 mm.; height, 18 mm. No. 3944, P. R. I.
4. Interior of right valve from zone 10, Calvert, locality 9, "Old Walls Place", Charles County. Length, 22 mm.; height, 19 mm. No. 3945, P. R. I.

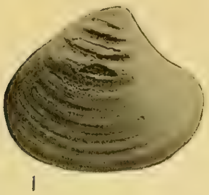
5. **Astarte cuneiformis** Conrad 38
Exterior of right valve of elongate form from zone 10, Calvert, locality 14, north of Randle Cliff Beach. Length, 31 mm.; height, 21 mm. No. 3946, P. R. I.

6. **Astarte cuneiformis** var. **parma** Dall 39
Exterior of right valve from zone 10, Calvert, locality 48, south of old Plum Point Wharf. Length, 23 mm.; height, 18 mm. No. 3947, P. R. I.

7. **Astarte exaltata** Conrad 43
Exterior of right valve from zone 10, Calvert, locality 9, "Old Walls Place", Charles County. Length, 17 mm.; height, 17 mm. No. 3948, P. R. I.

8-9. **Eucrassatella turgidula** (Conrad) 50
Right valve from zone 17, Choptank, locality 6, south of Jones Wharf. Length, 76 mm., height, 47 mm. No. 3949, P. R. I. Fig. 8, interior; fig. 9, exterior.

10. **Astarte exaltata** Conrad 43
Interior of same specimen as fig. 7.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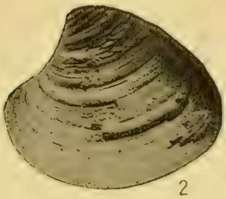
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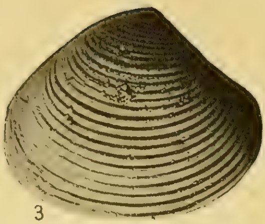
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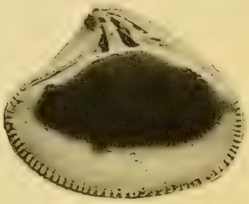
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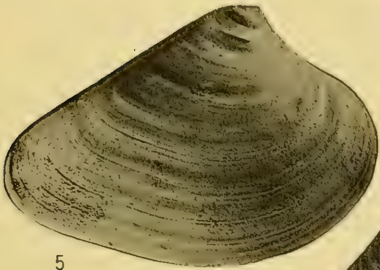
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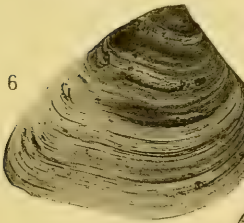
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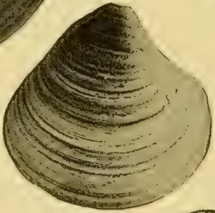
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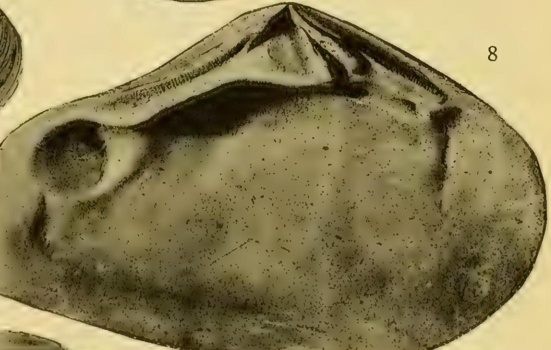
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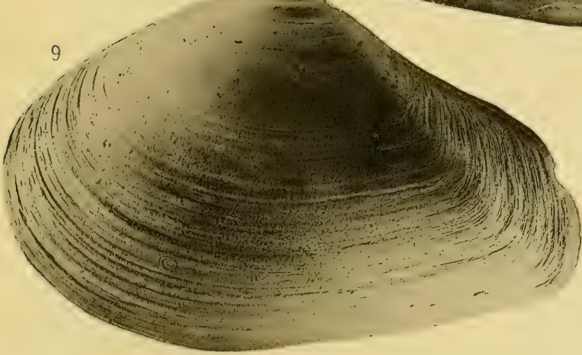
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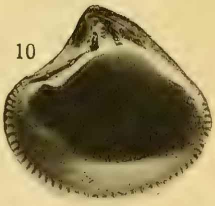
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PLATE 8 (26)

EXPLANATION OF PLATE 8 (26)

Figure Page

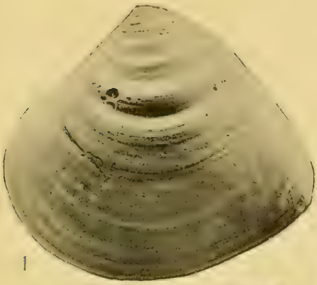
1. **Astarte thisphila** Glenn 46
   Exterior of left valve from zone 17, Choptank, locality 25, south of Calvert Beach. Length, 25 mm.; height, 22 mm. No. 3950, P. R. I.

2-3. **Eucrassatella marylandica** (Conrad) 51
   Right valve of young specimen from zone 19, Choptank, locality 55, south of Flag Pond. Length, 68 mm.; height, 46 mm. No. 3951, P. R. I. Fig. 2, exterior; fig. 3, interior.

4. **Astarte thisphila** Glenn 46
   Exterior of right valve from zone 17, Choptank, locality 27, north of Calvert Beach. Length, 28 mm.; height, 25 mm. No. 3952, P. R. I.

5. **Astarte obruta** Conrad 46
   Exterior of broken right valve from zone 19, Choptank, locality 15, north of Camp Conoy. Length, 25 mm.; height, 22 mm. No. 3953, P. R. I.

6. **Eucrassatella marylandica** (Conrad) 51
   Exterior of broken right valve from zone 19, Choptank, locality 15, north of Camp Conoy. Length of broken valve, 86 mm.; height, 61 mm. No. 3954, P. R. I.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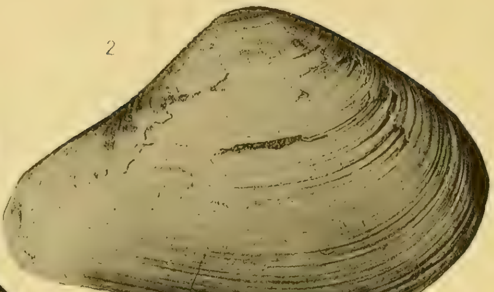
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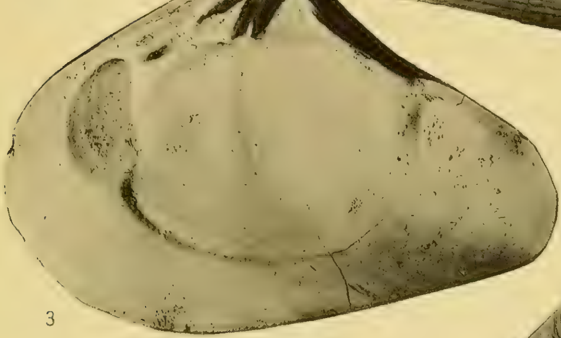
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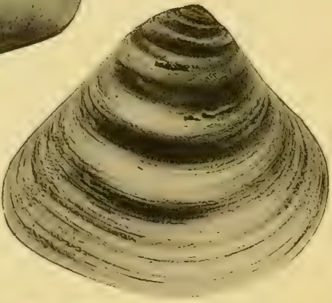
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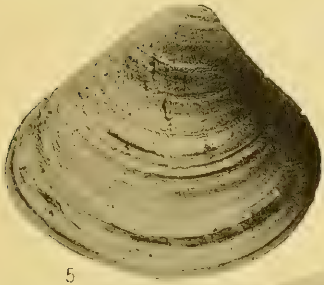
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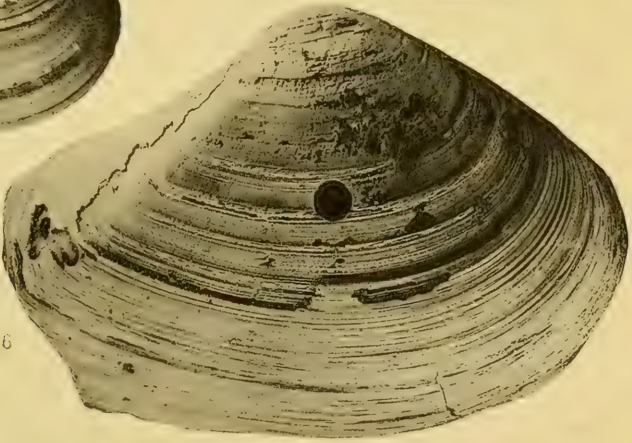
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PLATE 9 (27)

EXPLANATION OF PLATE 9 (27)

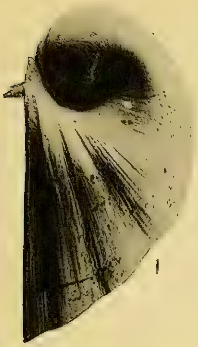
Figure Page

1-3. **Isocardia mazlea** Glenn 60
Left valve from zone 10, Calvert, locality 28, south of old Plum Point Wharf. Length, 45 mm.; height, 43 mm. No. 3955, P. R. I. Fig. 1, anterior; fig. 2, interior; fig. 3, exterior.

4. **Isocardia fraterna** Say, var. **marylandica,** n. var. 57
Holotype. Interior of right valve from zone 17, Choptank, locality 27, north of Calvert Beach. Length, 65 mm.; height, 51 mm. No. 3956, P. R. I.

5. **Isocardia fraterna** Say, var. **marylandica?,** n. var. 57
Exterior of left valve from three inches above the oyster bed, or from zone 5, Calvert, north of Randle Cliff Beach. Length, 42 mm.; height, 31 mm. No. 3957, P. R. I.

6. **Isocardia fraterna** Say, var. **marylandica,** n. var. 57
Holotype. Exterior of same specimen as fig. 4.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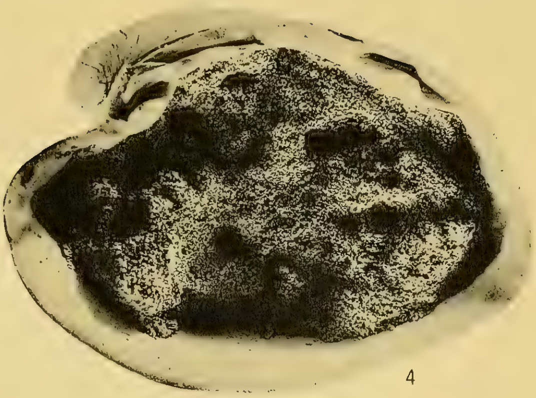
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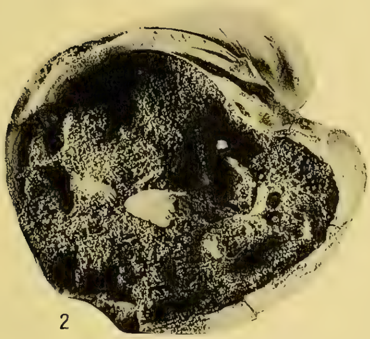
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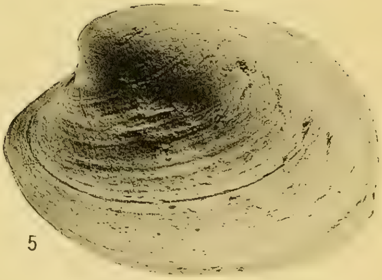
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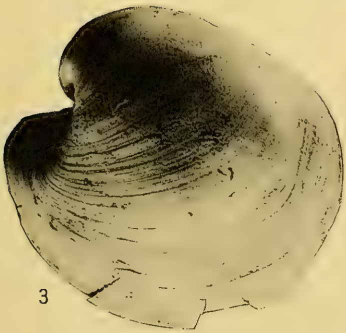
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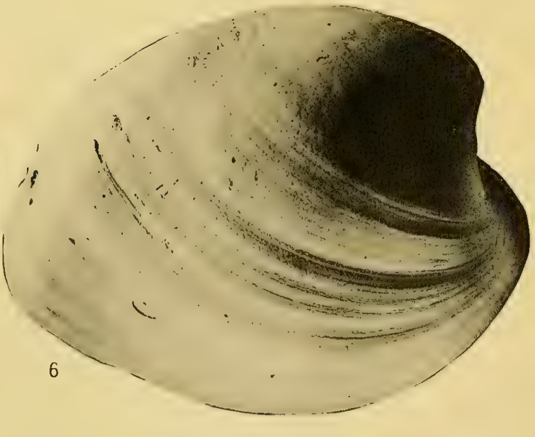
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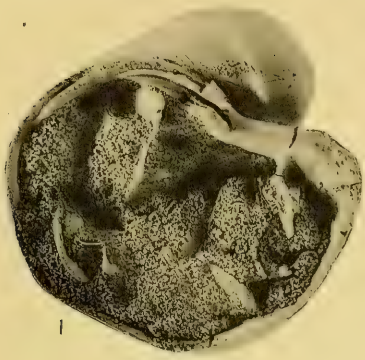
PLATE 10 (28)

EXPLANATION OF PLATE 10 (28)

Figure		Page
1-3.	**Isocardia markoëi** Conrad (emend.) .... Left valve from zone 10, Calvert, locality 28, south of old Plum Point Wharf. Length, 44 mm.; height, 44 mm. No. 3958, P. R. I. Fig. 1, interior; fig. 2, exterior; fig. 3, anterior.	60
4.	**Isocardia fraterna** Say, var. **marylandica**, n. var. .... Paratype. Exterior of right valve from zone 17, Choptank, locality 27, north of Calvert Beach. Length, 46 mm.; height, 36 mm. No. 3959, P. R. I.	57
5.	**Saxolucina (Megaxinus) anodonta** (Say) .... Exterior of left valve from zone 17, Choptank, locality 6, south of Jones Wharf. Length, 49 mm.; height, 50 mm. No. 3960, P. R. I.	53
6.	**Isocardia fraterna** Say, var. **marylandica**, n. var. .... Paratype. Exterior of left valve from zone 17, Choptank, locality 6, south of Jones Wharf. Length, 70 mm.; height, 56 mm. No. 3961, P. R. I.	57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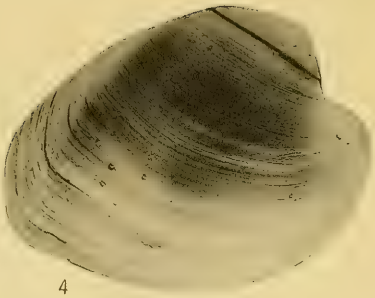
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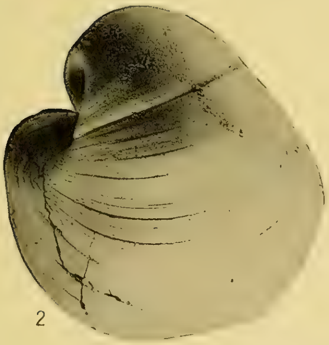
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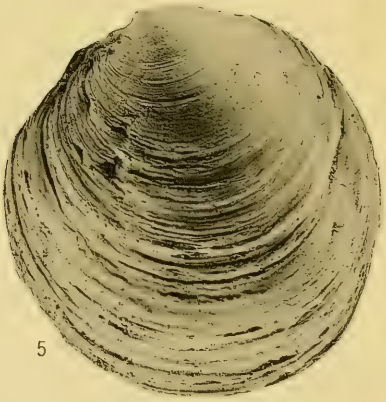
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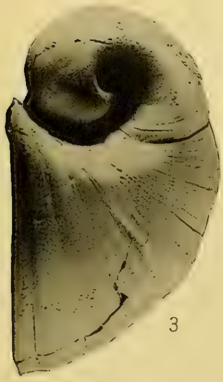
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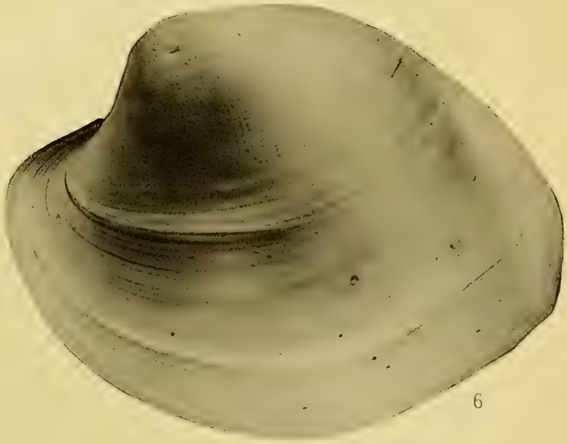
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PLATE 11 (29)

EXPLANATION OF PLATE 11 (29)

Figure		Page
1-2.	**Chione parkeria** Glenn	64
	1. Exterior of left valve from zone 14, Calvert, locality 45, south of Parker Creek. Length, 32 mm.; height, 27 mm. No. 3962, P. R. I. 2. Exterior of right valve from zone 14, Calvert, locality 45, south of Parker Creek. Length, 25 mm.; height, 20 mm. No. 3963, P. R. I.	
3-4.	**Chione latilirata** (Conrad)	63
	3. Exterior of left valve from zone 10, Calvert, locality 36, south of Randle Cliff Beach. Length, 16 mm.; height, 13 mm. No. 3964, P. R. I. 4. Exterior of right valve from zone 10, Calvert, locality 36, south of Randle Cliff Beach. Length, 17 mm.; height, 13 mm. No. 3965, P. R. I.	
5.	**Saxolucina (Megaxinus) foremani** (Conrad)	53
	Exterior of right valve from zone 10, Calvert, locality 48, south of old Plum Point Wharf. Length, 33 mm.; height, 32 mm. No. 3966, P. R. I.	
6-8.	**Antigona staminea** (Conrad)	61
	6. Exterior of right valve from zone 10, Calvert, locality 48, south of old Plum Point Wharf. Length, 26 mm.; height, 23 mm. No. 3967, P. R. I. 7. Exterior of right valve from zone 10, Calvert, locality 9, "Old Walls Place", Charles County. Length, 27 mm., height, 26 mm. No. 3968, P. R. I. 8. Exterior of left valve from zone 10, Calvert, locality 3, south of old Plum Point Wharf. Length, 28 mm.; height, 24 mm. No. 3969, P. R. I.	
9.	**Lucinoma contracta** (Say)	54
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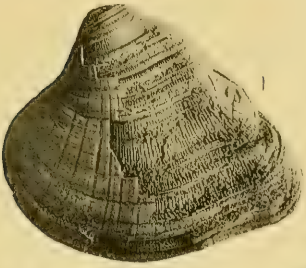
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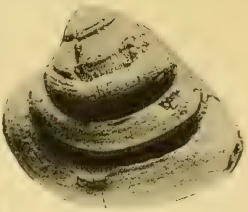
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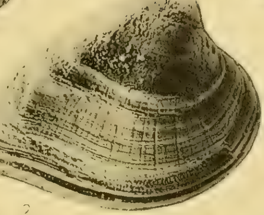
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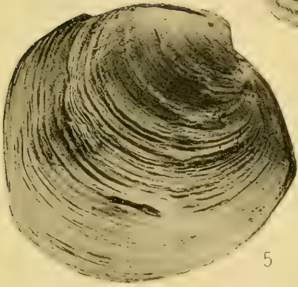
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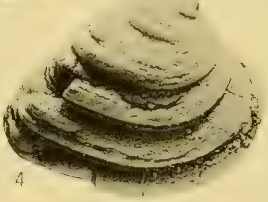
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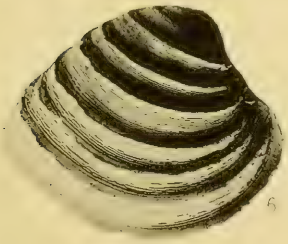
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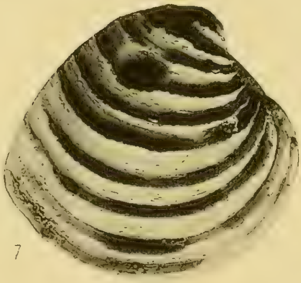
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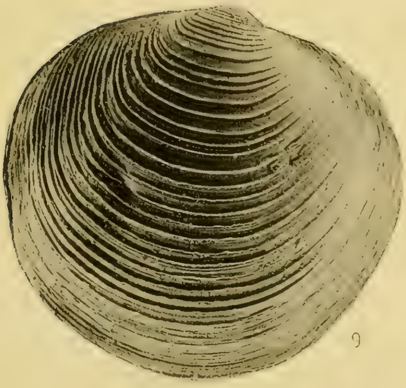
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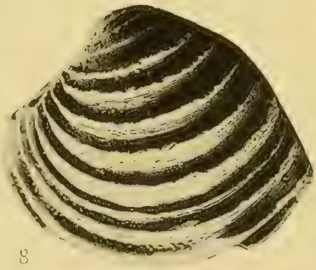
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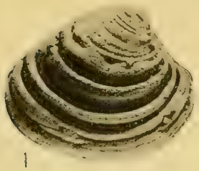
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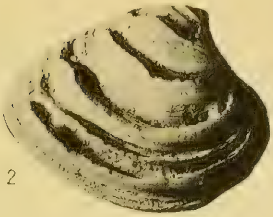
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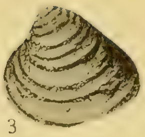
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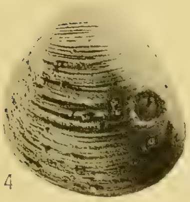
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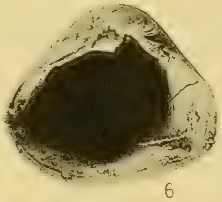
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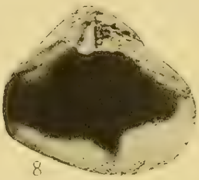
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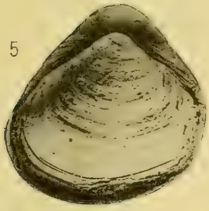
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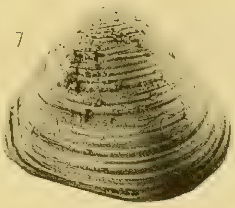
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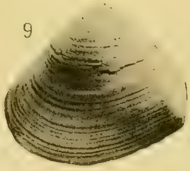
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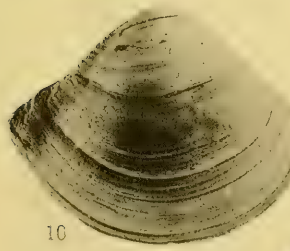
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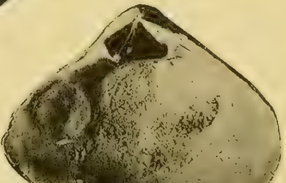
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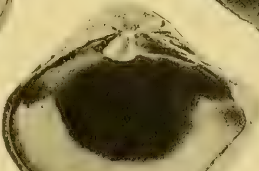

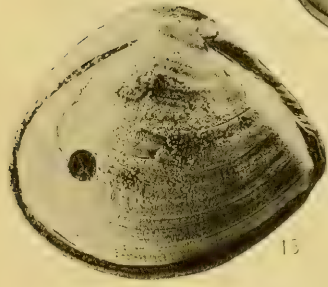
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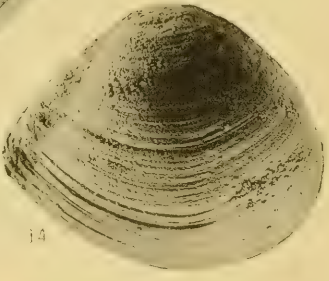
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